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MIDDLE NORTH SERIES
PRE-DICE THROW I, II, AND DICE THROW

Test Execution Report

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General Electric Company—TEMPO
7800 Marble Avenue, N.E., Suite 5
Albuquerque, New Mexico 87110

1 April 1978

Project Officer's Report for Period January 1975—June 1977

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Cratering	DICE THROW	Experiments	Shelters
M-X	Timing and Firing	Ammonium Nitrate Fueloil	

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This Test Execution Report describes all the fielding activities associated with Pre-DICE THROW I (Chapter I), Pre-DICE THROW II, Events 1 and 2 (Chapter II) and DICE THROW (Chapter III). Included in these descriptions are: test objectives, safety requirements, experimenters and support agencies, Test Group Staffs, test site locations and descriptions, charge configurations and stacking, schedules, instrumentation parks, cabling and power requirements, timing-and-firing and experiment or support descriptions. The Appendices include: countdown procedures, use of frequencies involved with experiments and

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20. ABSTRACT (continued)

fielding, drawing and document references and predictions of seismic, air-blast and cratering.

SUMMARY

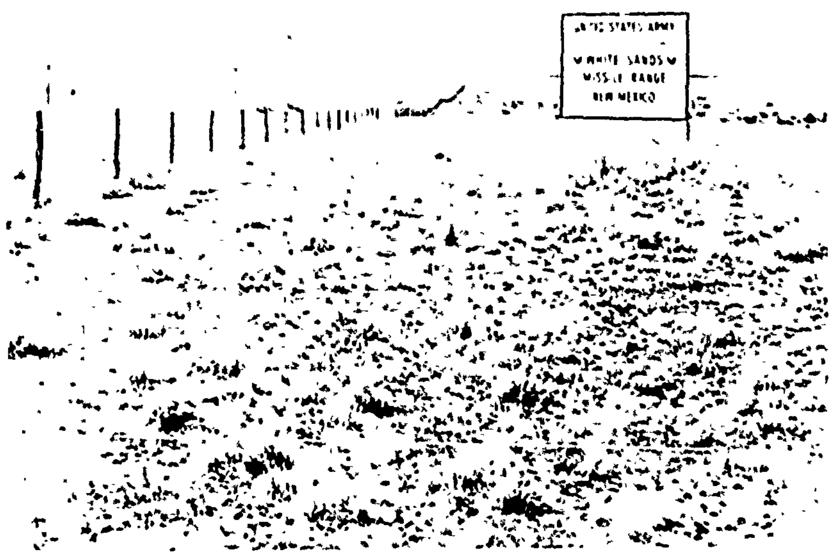
The DICE THROW events were the last programmed tests to be conducted in the MIDDLE NORTH series. It consisted of five phases: (1) a series of 1-lb (0.45-kg) tests to examine cratering and fireball effects due to explosive configuration and charge detonation system variations in a highly controlled test medium, (2) a series of 1000-lb (453.6-kg) equivalent events to gain experience with Ammonium Nitrate Fuel Oil (ANFO) and also to examine cratering and fireball effects in a common media using both TNT and ANFO charges, (3) a series of 5-ton (4.5-metric ton) equivalent events to identify the most likely ANFO source configuration, (4) a series consisting of two 100-ton (90.7-metric ton) equivalent events in a geology of Air Force interest to verify the program compliance to objectives and to provide detailed data to support charge performance characterization of a 500-ton (453.6-metric ton) equivalent event, and (5) the 500-ton (453.6-metric ton) equivalent event.

Phases 1 through 4 were called the ANFO Charge Development Program with Phases 1 and 2 conducted on Kirtland Air Force Base, Albuquerque, New Mexico. Phases 3 and 4 were conducted on the White Sands Missile Range (WSMR) at the Queen 15 location and were titled Pre-DICE THROW I and II, respectively. These series of events are described in detail in Chapters I and II. Chapter III describes Phase 5 of the program called DICE THROW. This test was conducted at the Giant Patriot site also located on WSMR. The overall program was conducted in the January 1975 through June 1977 time frame with a total of 42 agencies participating.

Each chapter in this Test Execution Report (TER) describes the fielding activities associated with the last three phases of the test program. The following are among those items discussed: objectives of the test, the experimenters and support agencies, FCTMOT Test Group Staff and their responsibilities, site location and description, charge configuration and stacking, schedule of main events, instrumentation park arrangements, cabling requirements, timing and firing, power requirements and experimenter or support descriptions.

This text includes both the English and Metric systems of engineering units. Deviations from this occur when tables or illustrations are too detailed for practical inclusion. In these cases, scales or conversion factors are provided for the reader's convenience.

There are two Appendices in this report which contain details on engineering countdown procedures, use of frequencies and references to drawings and Project Officers Reports and DICE THROW predictions.



WELCOME TO WHITE SANDS MISSILE RANGE AND THE DICE THROW PROGRAM

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CHAPTER I

PRE-DICE THROW I TEST EXECUTION REPORT

INTRODUCTION

The Pre-DICE THROW I program, conducted at the Queen 15 site on the White Sands Missile Range (WSMR), was the third phase of the charge configuration program, and this chapter describes only that portion.

Pre-DICE THROW I consisted of four events: one TNT surface-tangent sphere, and three ANFO surface-tangent right cylinders with hemispherical caps. The major objective of this program was to develop an ANFO charge configuration that would match the ground-motion and cratering characteristics of a surface-tangent sphere of TNT and would eliminate or minimize jetting. The surface-tangent sphere was detonated for site calibration. Details concerning the preliminary charge configuration program may be found in the ANFO Charge Development Program, Program Summary, written by Capt. T. Y. Edwards, 12 June 1977. This report describes the first two phases of the DICE THROW charge-development program conducted at Kirtland Air Force Base (KAFB).

The safety requirements for Pre-DICE THROW I are contained in the Safety Standard Operating Procedures for Pre-DICE THROW Explosive Operations - SOP 224-14-75, 27 March 1975. This document includes: Operation No. 1, Off-Loading and Placing TNT Spheres; Operation No. 2, Firing Hook-Up and Detonation (TNT); Appendix I, High-Voltage Firing System Description; Operation No. 3, Off-Loading and Filling ANFO Charge Container; Operation No. 4, Firing Hook-Up and Detonation (ANFO Events 2 and 4) with a letter requesting changes to Operation No. 4 to reflect changes required for the last ANFO event dated 23 July 1975 by Mr. Hector F. Lozano, Chief, Warheads Branch; Operation No. 7, Off-Loading and Stacking ANFO Charge (Stacked Configuration); Annex A, Stacking Plan 6 Tons ANFO.

Survey information pertaining to GZ-1, -3 and -4 are found in Survey Report No. 328-75, 15 May 1975. Also included in this report are the surveyed positions for each camera mound.

Details pertaining to the selection of the Queen 15 site on the WSMR (see Figure 1-1) for the Pre-DICE THROW events may be found in the Air Force Weapons Laboratory (AFWL) Letter Report "DICE THROW Site Selection Final Report." The Queen 15 site is located approximately 80 miles (128.75 km) north of the main post area of the range and approximately 15 miles (24.14 km) west of the nearest boundary of the range. The site, at an elevation of 4258 feet (1297.84 m), is on the northwestern edge of the Tularosa Basin and adjacent to the northwestern portion of the San Andres Mountain Range. The climate, vegetation and biota are fairly typical to that of other basin areas in the southwest. A hydrologic section and water level contours are shown in Figures 1-2 and 1-3.

Pre-DICE THROW I FCTMOT Staff

LCDR Bill Edgerton - Test Group Director
Capt. Tom Edwards - Technical Director
Maj. Les Langseth - Test Group Engineer
Maj. Rich Palaschak - Program Coordinator
Mr. Lou Stefani - Program Analyst
Mr. Noel Gantick - Instrumentation Engineer
Mr. Joe Sneed - Safety Engineer

Experimenters and Support Agencies

1. Air Force Weapons Laboratories (AFWL)
2. Civil Engineering Research Facility (CERF)
3. Denver Research Institute (DRI)
4. U. S. Air Force Aerospace Audio Visual Services (AAVS)
5. U. S. Army Electronics Proving Ground (EPG)
6. EG&G, Inc.
7. General Electric—TEMPO
8. White Sands Missile Range (WSMR)
9. Waterways Experiment Station (WES)

Charge Descriptions

Figure 1-4 shows photographs of the TNT surface-tangent sphere (Event 1 detonated on 16 April 1975). Table 1-1 describes the sphere and booster-detonator system. The original TNT sphere to be used on

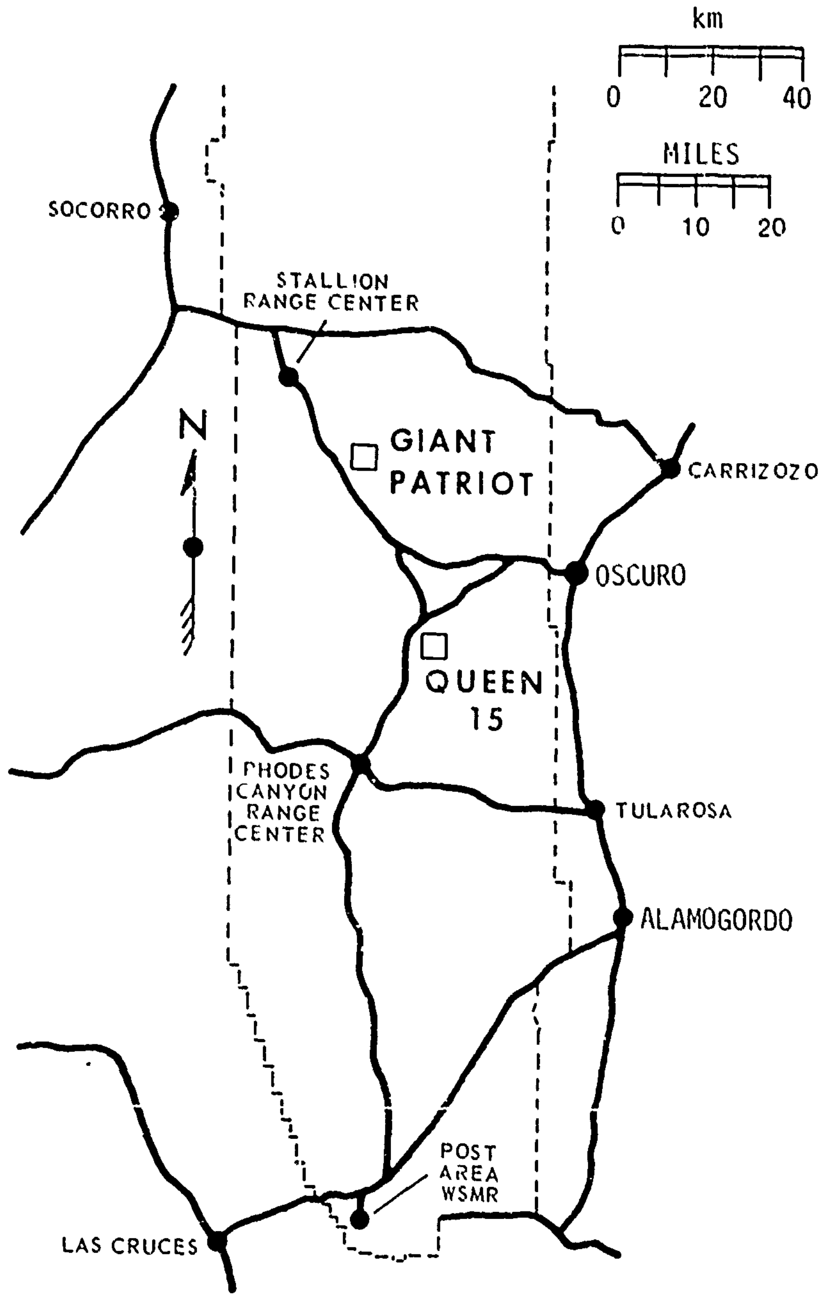


Figure 1-1. Test Site Location,
Pre-DICE THROW I and II

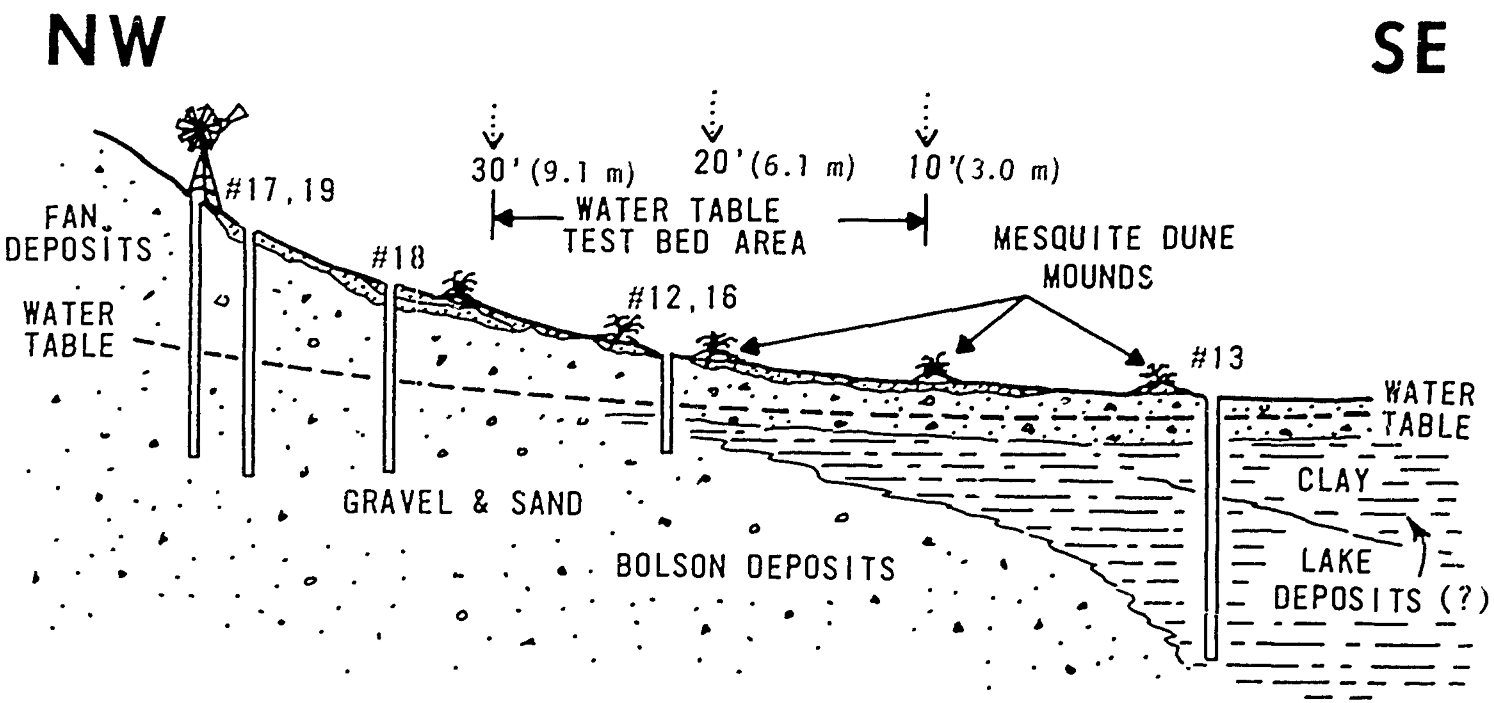


Figure 1-2. QUEEN 15 Hydrologic Section (Diagrammatic), Pre-DICE THROW I

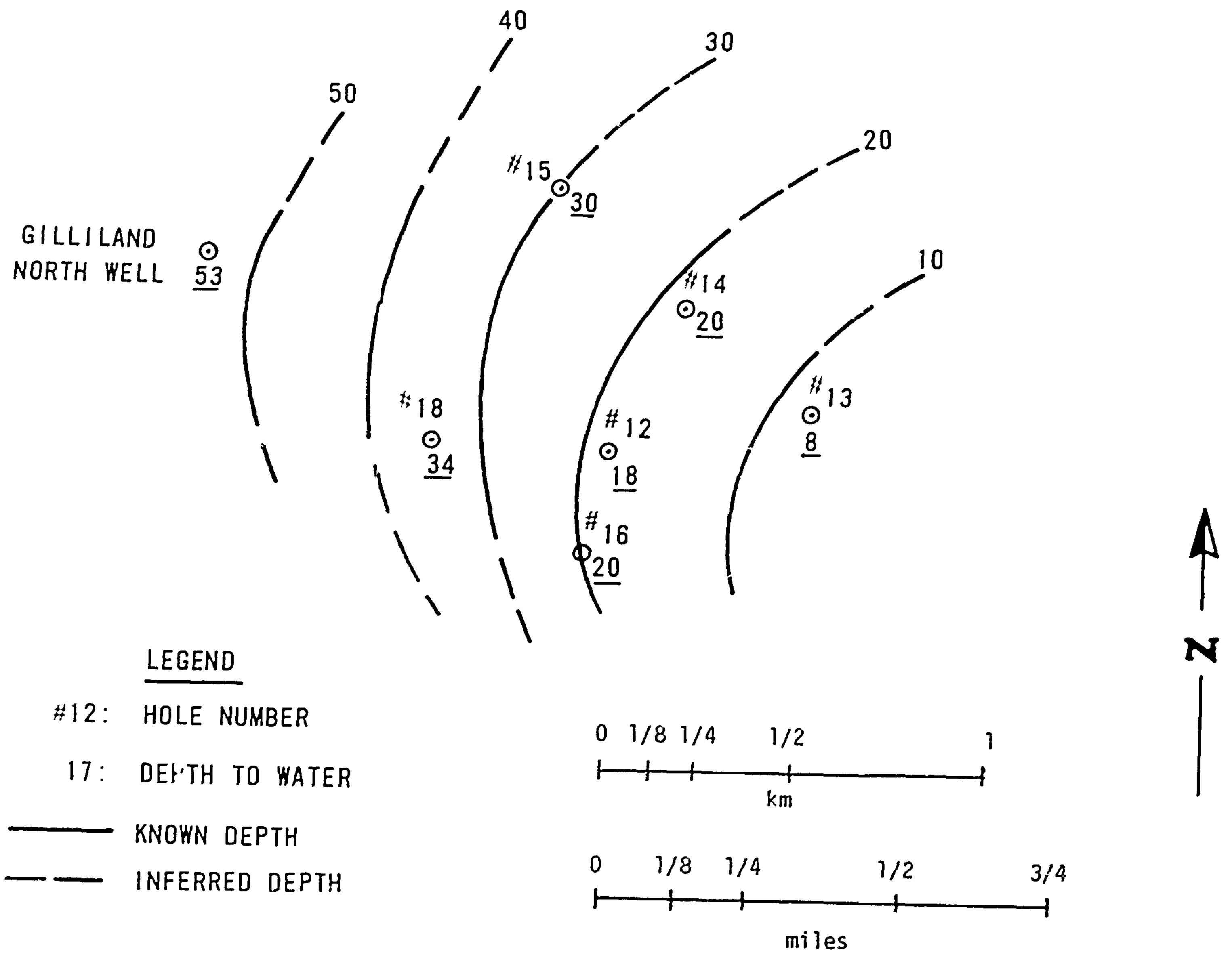
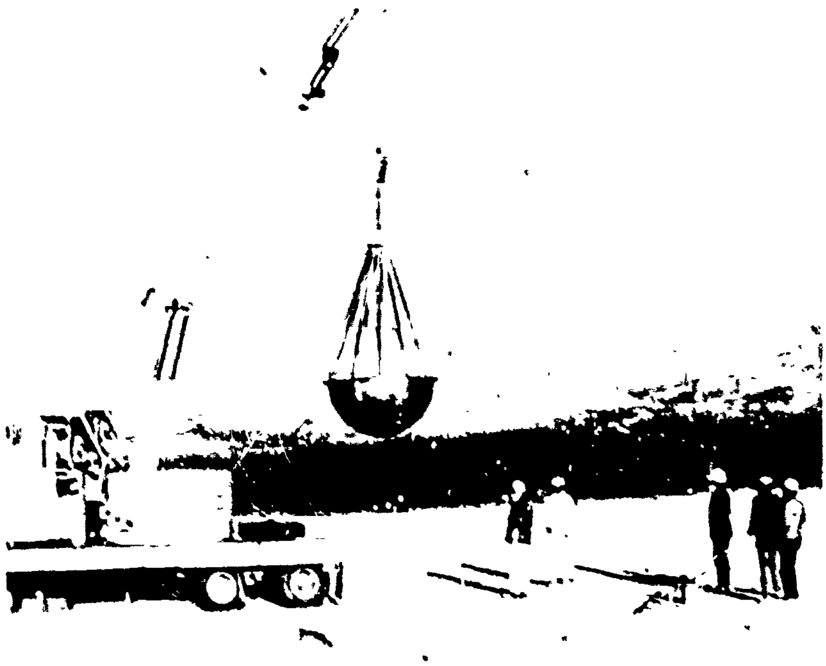


Figure I-3. Depth to Ground Water - DICE THROW I Test Site



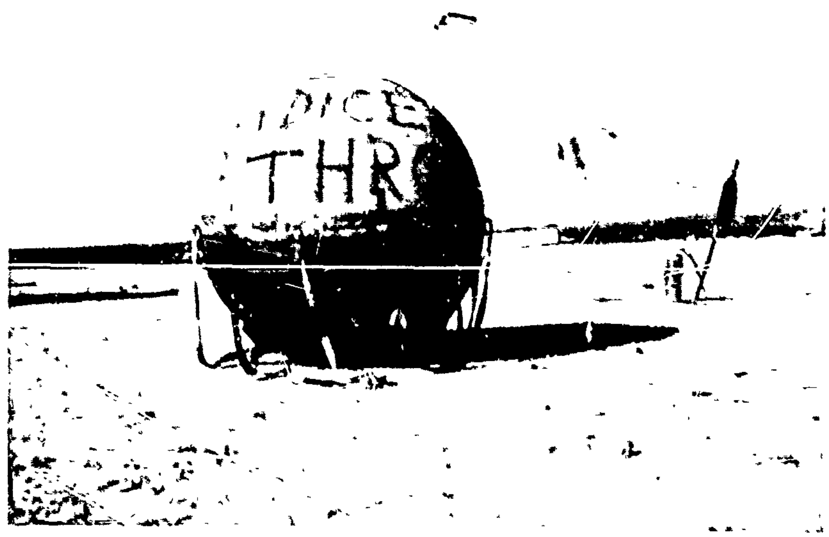


Figure 1-4. Photographs of TNT Sphere, Pre-DICE THROW I

Table 1-1. Pre-DICE THROW I Charge Configuration and Detonation Details

Event No.	CERF Desig.	Type of Explosive	Total Wt. of Explosive	Booster Type & Wt.	No. of Boosters	RP-1 No. of Detonators	Configuration (Refer to Figure)	Remarks
1	PDTI-1	TNT	9,300 lbs (4,218.41 kg)	Pentolite (16-in diameter) (40.64-cm)	1	2	Surface-Tangent Sphere, Figure 1-4	
2	PDTI-2	ANFO	11,045 lbs (5,009.93 kg)	C-4 90 lbs (40.82 kg)	5	9	Capped Cylinder, Figures 1-5 and 1-7	4 ea 20 lbs (9.07 kg) 1 ea 10 lbs (4.54 kg)
3	PDTI-3	ANFO	11,455 lbs (5,195.90 kg)	C-4 90 lbs (40.82 kg)	5	9	Capped Cylinder, Figures 1-5 and 1-7	4 ea 20 lbs (9.07 kg) 1 ea 20 lbs (4.54 kg)
4	PDTI-4	ANFO	11,155 lbs (5,059.82 kg)	C-4 42 lbs (19.05 kg)	7	13	Capped Cylinder, Figure 1-8	7 ea 6 lbs (2.72 kg)

this event had to be destroyed because of an immovable wooden plug that had been inserted into the arming port.

The charges for Events 2, 3 and 4 are described in Table 1-1 and in Figures 1-5 and 1-6 (these were detonated on 30 April, 14 May and 31 May 1975). Figures 1-7 and 1-8 show photographs of the ANFO charges for Events 2, 3 and 4.

Timing-and-Firing System

1. Timing

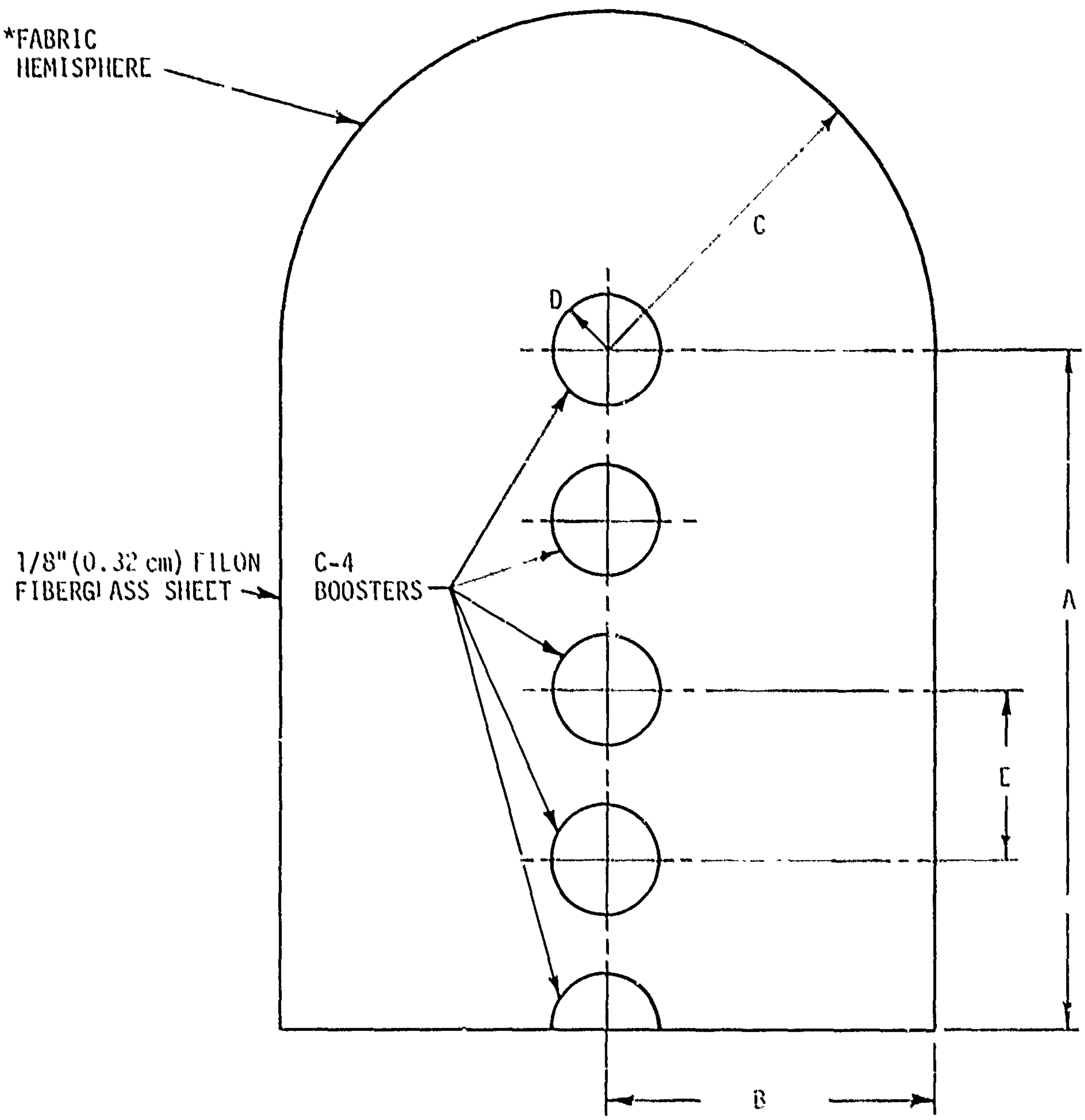
The AFWL and CERF provided the timing and firing (T&F) for this series of events. All T&F functions were handled through the AFWL instrumentation van. Table 1-2 indicates the timing functions and signals that were required by each experimenter.

2. Firing

A block diagram of the firing system used at Queen 15 is depicted in Figure 1-9. The firing unit is a TC-130A field X-unit and is used to fire RP-1 exploding bridgewire detonators. This unit was operated from a control unit that was located in an instrumentation and test control van. A TC-369 transverter charged the X-unit to 3000 volts and provided a preset interlock capability that assured that the X-unit was charged to the proper operating voltage before the system could be enabled to fire. A 30-volt, 10-amp DC power supply provided power to operate the system. The firing pulse was a 28-volt signal from the countdown sequencer that triggered the firing system and was effective only after interlock release and manual arming were completed. Refer to SOP 224-14-75, Safety Standard Operating Procedures, 27 March 1975.

System Operation

The typical sequence of events for using this system were as follows: The arming party had the keys to the firing system and a lock box in which all cables going to the field components had been secured. Once the arming party had completed hookup of explosives, they returned the keys to the control unit operator. At the appropriate time in the countdown, the keys to the lock switches were inserted and



ANFO EVENT NO. in. (cm)	A	B	C	D	E
2	61.15 (155.32)	36.36 (92.35)	36.36 (92.35)	4.4 (11.18)	15.3 (38.86)
3	40.92 (103.94)	40.92 (103.94)	40.92 (103.94)	4.4 (11.18)	10.24 (26.01)

*NOTE: The cap fabric on Event 1 was bleached muslin
The cap fabric on Event 2 was canvas

Figure 1-5. Pre-DICE THROW I, Events 2 and 3 Charge Details

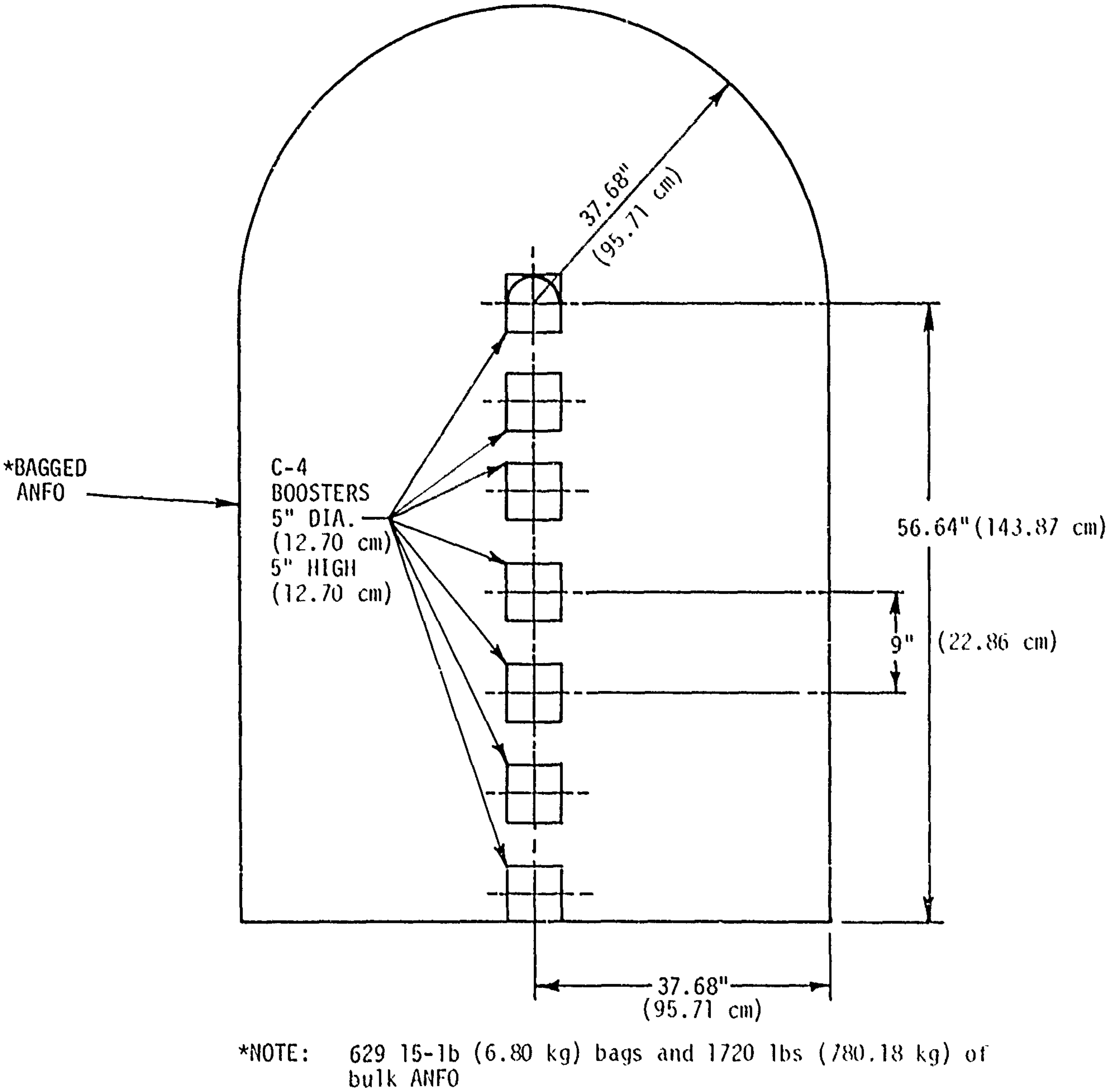


Figure 1-6. Pre-DICE THROW I, Event 4 Charge Details

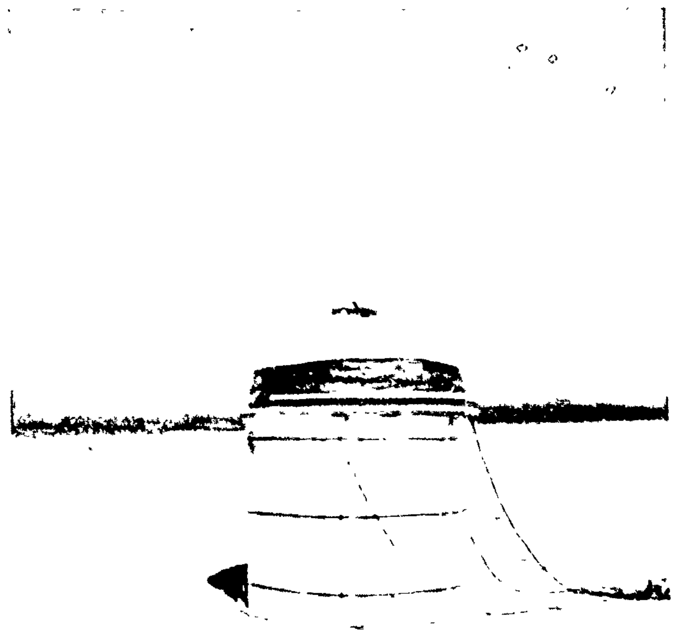
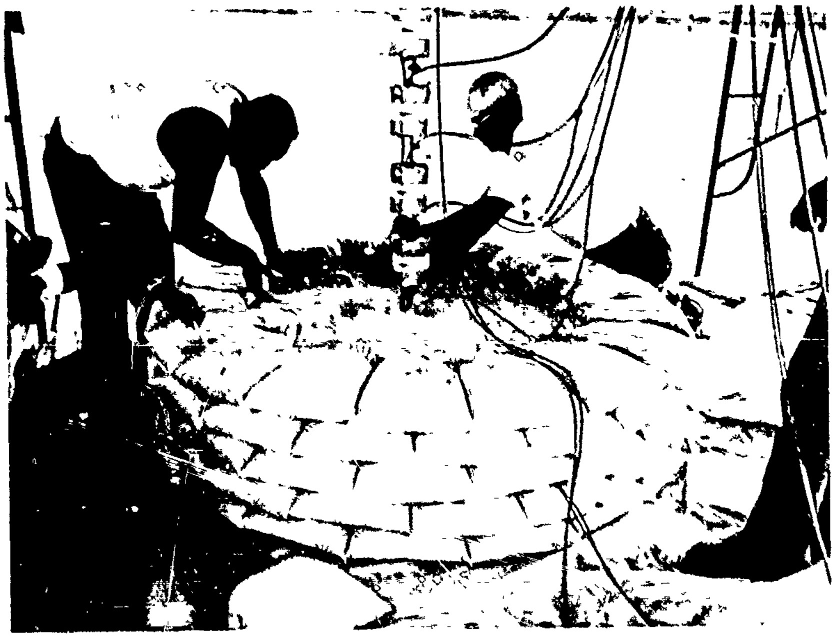


Figure 1-7. Top Photograph Bulk ANFO Charge Event 2
Bottom Photograph Bulk ANFO Charge Event 3,
Pre-DICE THROW I



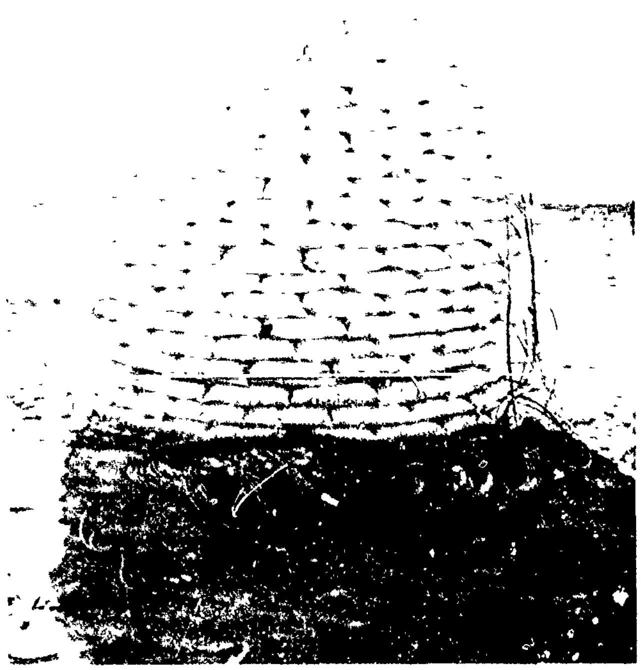


Figure 1-8. Stacked ANFO Charge Event 4, Pre-DICE THROW I

Table 1-2. Pre-DICE THROW I Timing Function Requirements

	T-40 sec	T-30 sec	T-5 sec	T-3 sec	T-0.9 sec	T-0.1 sec	T-0 sec	IRIG B	FIDU	Remarks
AFWL/CERF	X*	(2) X						X	X	*Reset signal
AFWL-SEISMIC			(1)* X	X*			(1) X			Closures with +28 VDC *Closure at T-5 sec and open at T-3 sec
DRI-PHOTO			(1) X		(1) X	(1) X			X	All closures are latching.
NRD-PHOTO	(1) X									Latching
ARMTE								X	X	For 1st ANFO event only
	T-40 sec	T-30 sec	T-5 sec	T-3 sec	T-0.9 sec	T-0.1 sec	T-0 sec	IRIG B	FIDU	NOTE: The number in parantheses indicates the contact requirements.

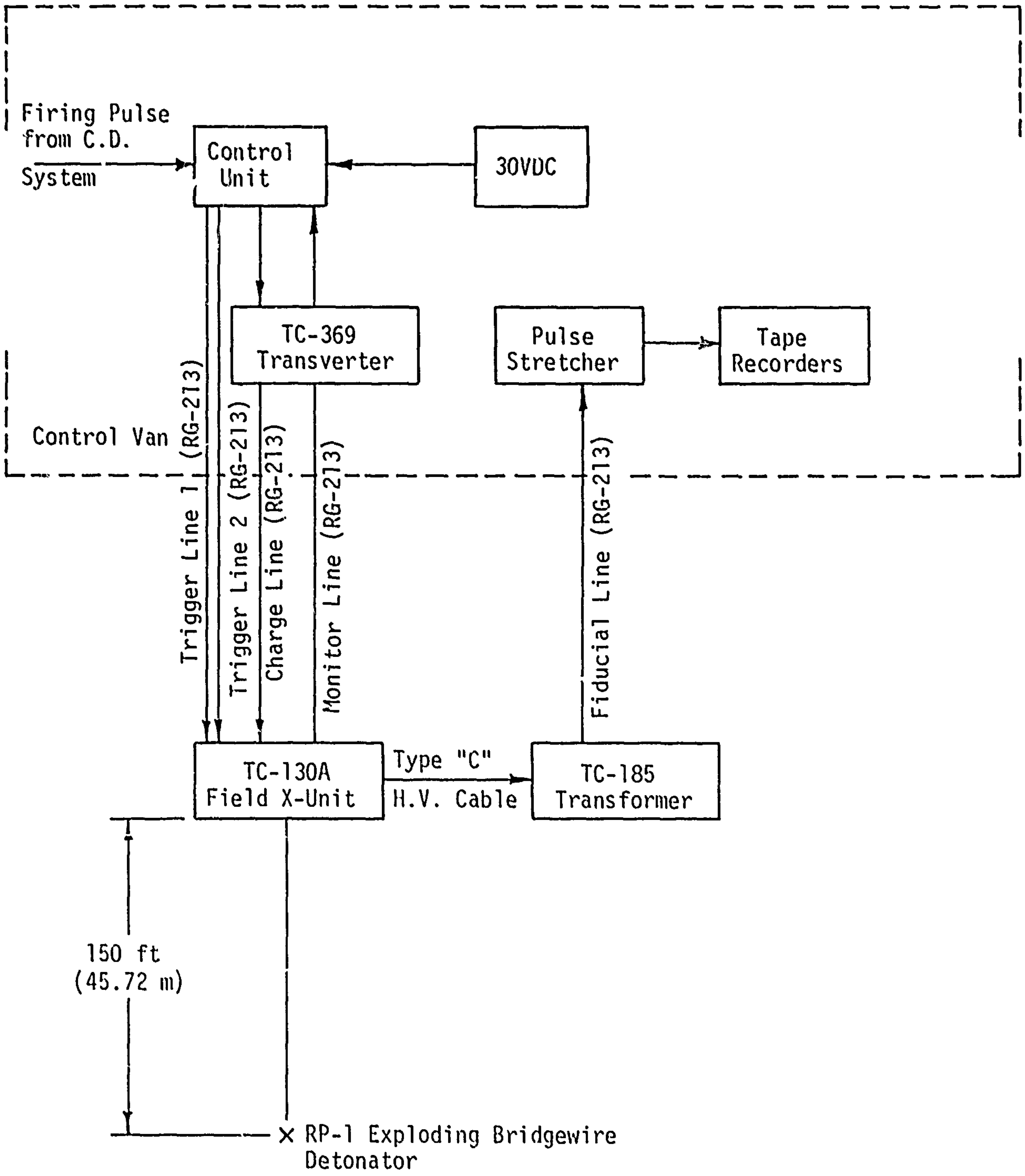


Figure 1-9. Firing System, Pre-DICE THROW I

turned on. The pre-arm switch was then actuated. This turned on the TC-369 and charged the X-unit to 3000 volts. The monitor return line connected the X-unit voltage to the monitor section of the TC-369 and tripped an interlock relay in the TC-369 when the TC-130A was charged to 2800 volts. The ARM switch was then turned on, completing the trigger circuitry. (This is enabled only after the H. V. interlock has actuated.) When the countdown sequencer provided a 28-volt fire pulse, relays were actuated providing a fire pulse to the trigger inputs of the TC-130A. The unit discharged, firing the detonator, and returned an isolated, stepped-down signal to be stretched and recorded on tape by the experimenters for fiducial.

Queen 15 Pre-DICE THROW I Site and Experiment Layout and Description

Site Description

Figure 1-10 depicts the overall site layout, indicating camera stations, access roads, instrumentation van and cable overrun areas. The test bed, as shown in this figure, was cleared of vegetation by a grader to minimize fire hazards and to provide for unobstructed photographic coverage of each event. An expanded view of this area is shown in Figure 1-11 which indicates the orientation of each of the primary and secondary gage lines for each event. Refer to the AFWL "DICE THROW Site Selection Final Report," letter report to Capt. Edwards, FCDNA/FCTD-TI from DEV for details on the Pre-DICE THROW site selection.

Experiment Description

1. AFWL/CERF - Project Officers: Dr. R. Henny (AFWL) and Mr. G. Jones (CERF)

OBJECTIVES: Airblast, Ground Motion, Strong Motion, Seismic, Detonation Velocity, Ejecta Collection, Displacement Pins, and Sand Columns. Photographs of the gages used for these measurements are shown in Figures 1-12, 1-13, 1-14 and 1-15.

All events (except the last ANFO event) had four radials (90 degrees apart) of displacement pins and ejecta collectors, and sand columns along one anticipated crater diameter. Strong-motion measurements were also made on the first three events.

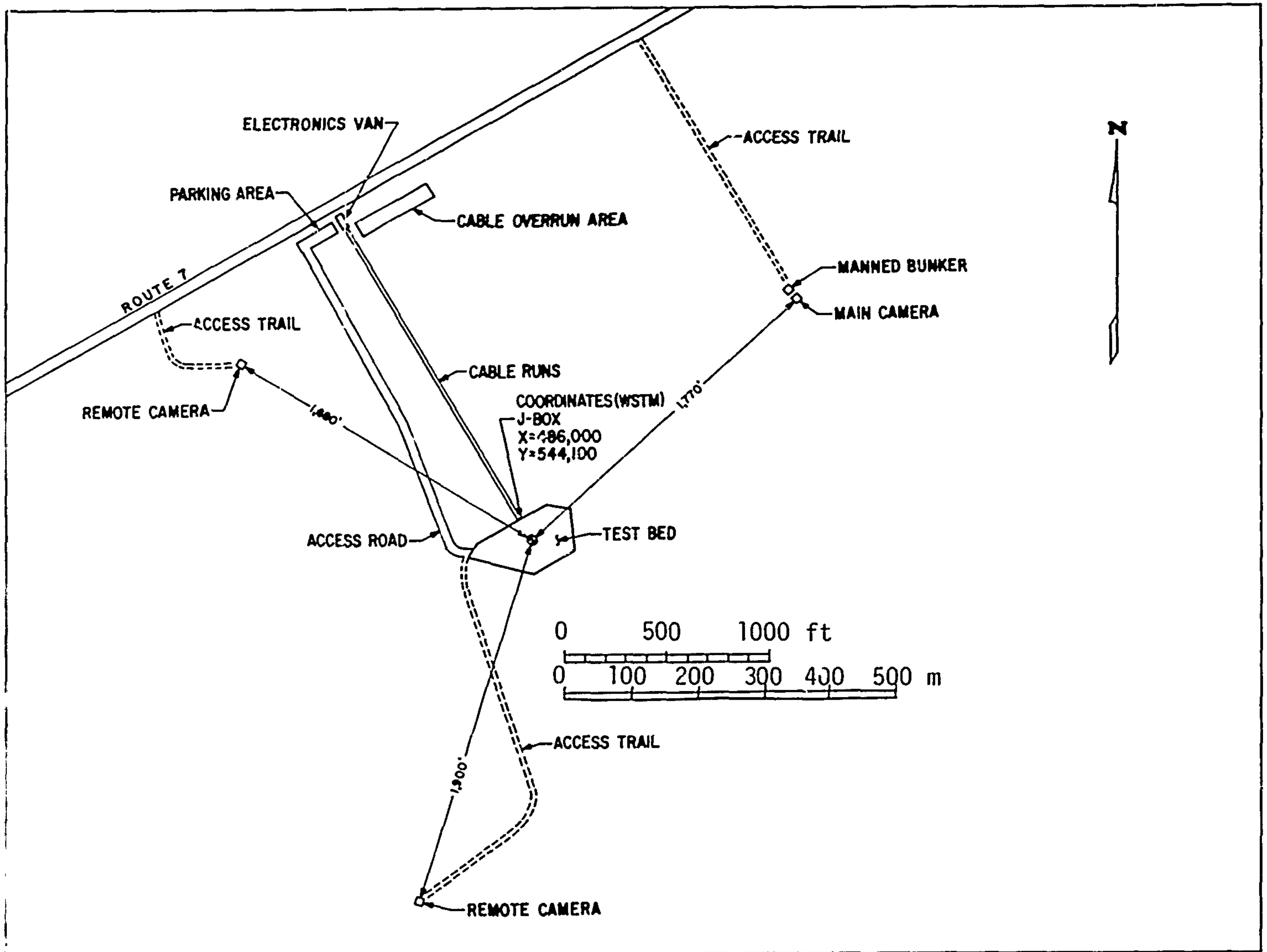


Figure 1-10. Site Layout - 5-Ton Events, Pre-DICE THROW I

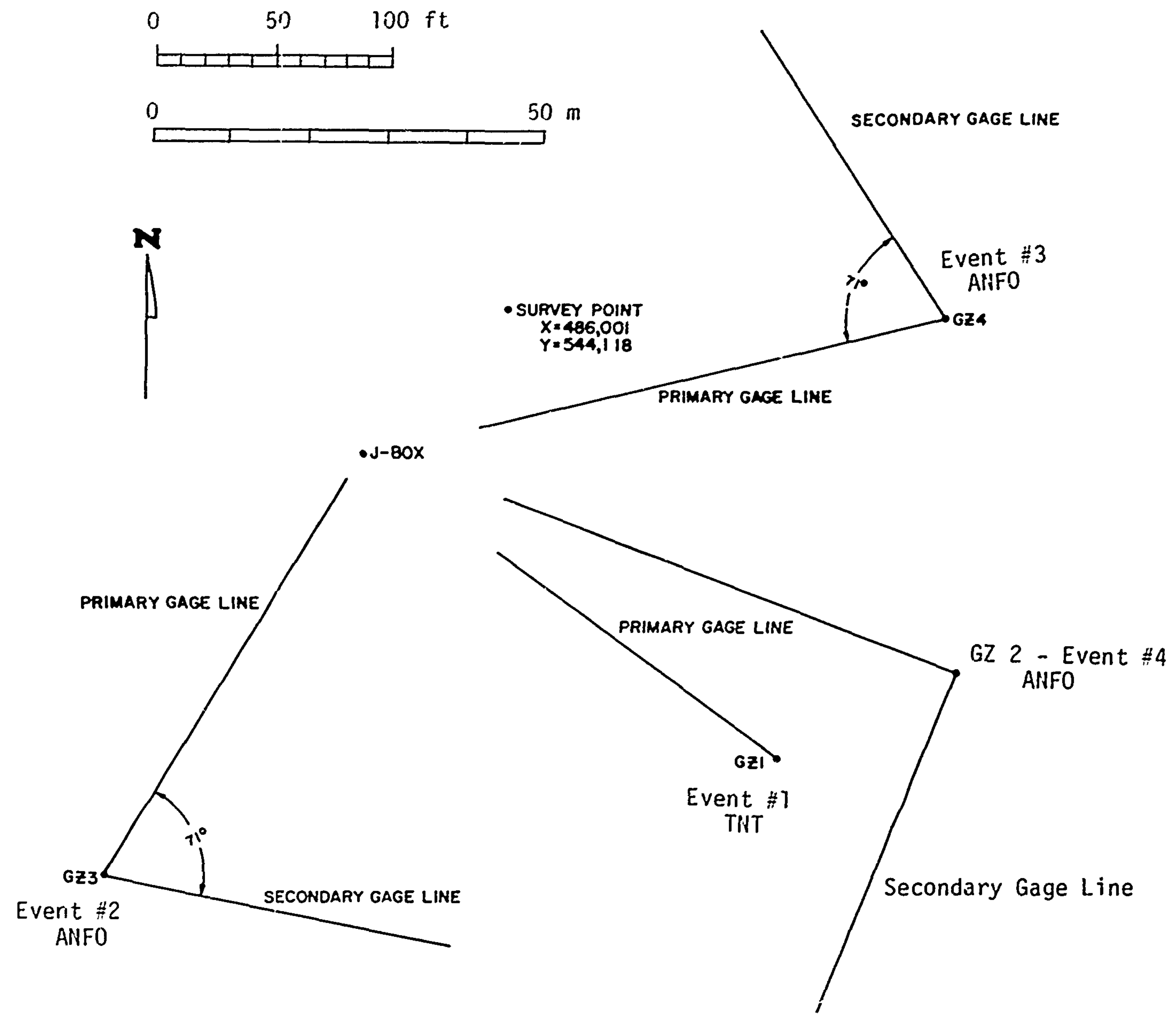


Figure 1-11. Test-Bed Layout, Pre-DICE THROW I

Figure 1-12. Airblast Gages (Top Photo) and Instrumentations Cable Protection Pipe (Bottom Photo), Pre DICE THROW I

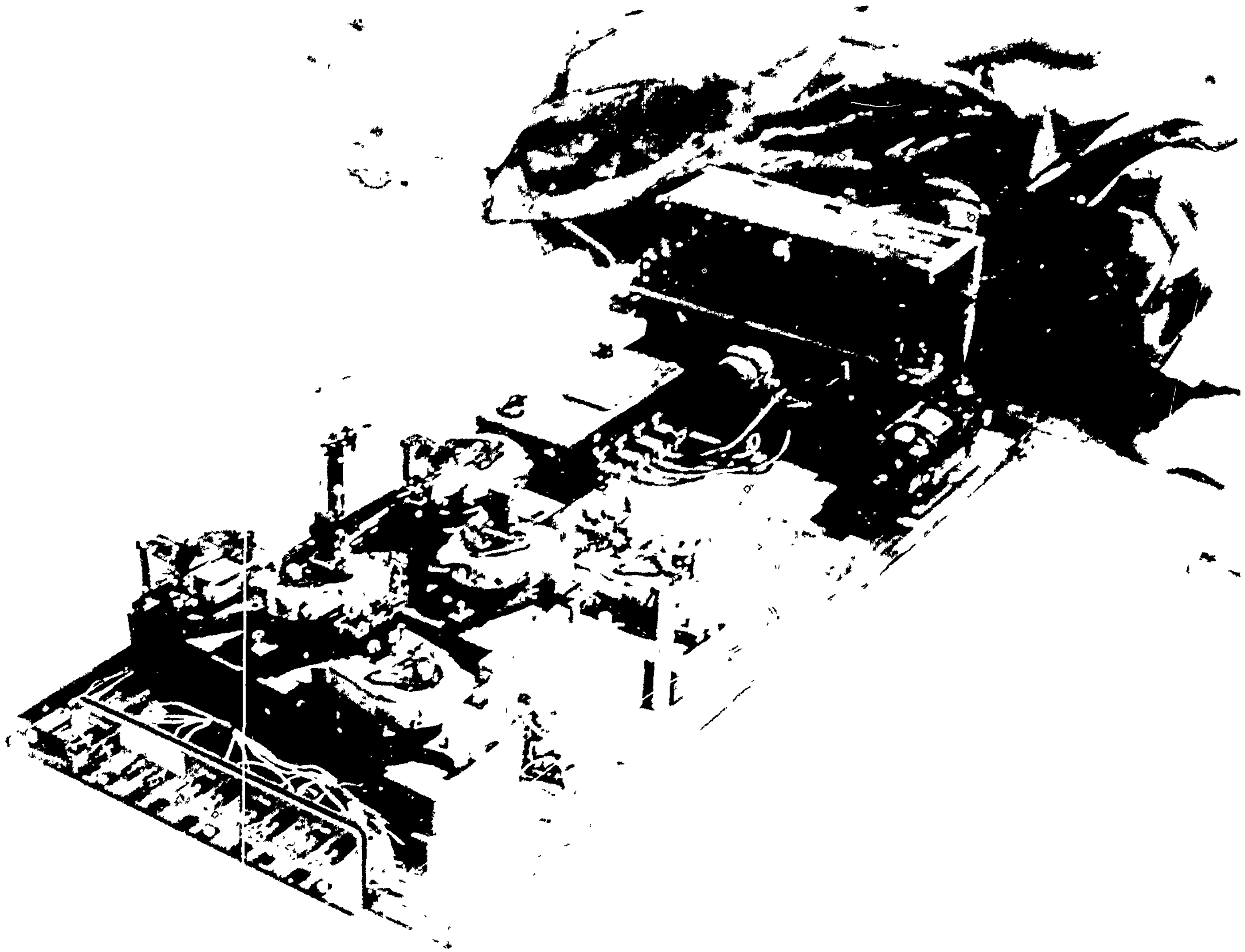


Figure 1-13. Exposed View of Seismograph Station Used on Pre-DICE THROW I

Figure 1-14. Photographs of Ground Motion Canisters, Pre-DICE THROW I

Figure 1-15. Ejecta Collectors Used on Pre-DICE THROW I

The displacement pins (33 on each radial) were placed in the ground starting at 16 ft (4.88 m) from ground zero (GZ) and spaced at 1-ft (0.30-m) intervals out to 35 ft (10.67 m); 5-ft (1.52-m) intervals out to 80 ft (24.38 m); and 10-ft (3.05-m) intervals out to 120 ft (36.58 m). Each of these pins was surveyed prior to and after each event.

The ejecta collectors were placed along each of the four radials (adjacent to the displacement pins) starting at 32 ft (9.76 m) from GZ, with a separation of 8 ft (2.44 m) out to 80 ft (24.38 m), and 16 ft (4.88 m) out to 160 ft (48.77 m) for a total of 12 ejecta collectors on each radial.

Sand columns were placed in the ground along one diameter with a 3-ft (0.91-m) separation out to 18 ft (5.49 m) on either side of GZ. The 13 sand columns were all 12 ft (3.66 m) deep. These columns were excavated after each event to determine the true crater dimensions.

The AFWL's strong-motion seismographs were used to measure radial, tangential and vertical displacements and accelerations. This seismograph is an optical-mechanical instrument that records (on 12-in. (30.48-cm)-wide photographic paper) earth-particle motion in direct terms of acceleration and displacement. The main components of the seismograph are the starting devices, accelerometers, Carder Displacement Meters, and the timing device. (Refer to Figure 1-13.)

Eight of these seismographs were placed along one radial line south of GZ. They were located at 300, 400, 500, 650, 900, 1400, 1800 and 2400 ft (91.4, 121.9, 152.4, 198.1, 274.3, 426.7, 548.6, and 731.5 m) from GZ. Each of these instruments was remotely activated by a hot closure (+28 volts dc) from the T&F van. There were a total of 48 channels recorded (6 from each instrument package).

(1) Event No. 1, 9300 lbs (4218.41 kg) TNT Surface-Tangent Sphere, 16 April 1975.

This event was the site calibration shot and required only one gage line as shown in Figure 1-16. There were a total of seven overpressure and 32 ground-motion measurements made. The charge had a Pentolite booster which was detonated with two detonators.

(2) Event No. 2, 11,045 lbs (5009.93 kg) ANFO, Capped Cylinder with a cylinder length to diameter (L:D) of 0.84:1, 30 April 1975.

This was the first ANFO event of the series. The charge had five C4 boosters (four spheres with two detonators each and one hemisphere with one detonator) as shown in Figure 1-5. There were a total of 12 overpressure and 32 ground-motion measurements made, as shown in Figure 1-17.

(3) Event No. 3, 11,455 lbs (5195.90 kg) ANFO, Capped Cylinder with an L:D of 0.5:1, 14 May 1975.

This event was instrumented the same as event No. 2. The booster arrangement and detonation method were also the same. Refer to Figure 1-17.

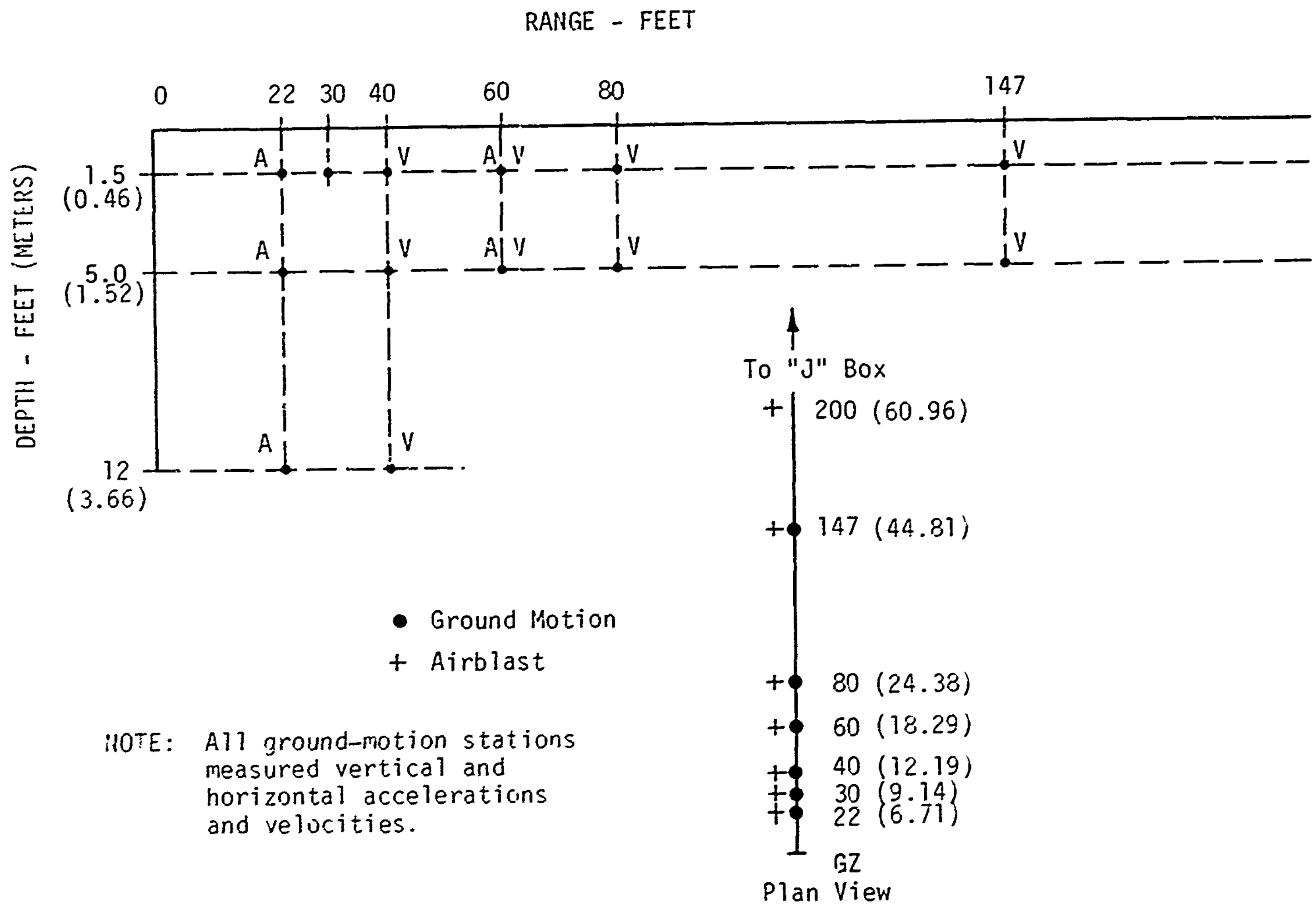


Figure 1-16. Pre-DICE THROW I - Event 1, TNT Surface-Tangent Sphere, Airblast and Ground-Motion Measurement Stations

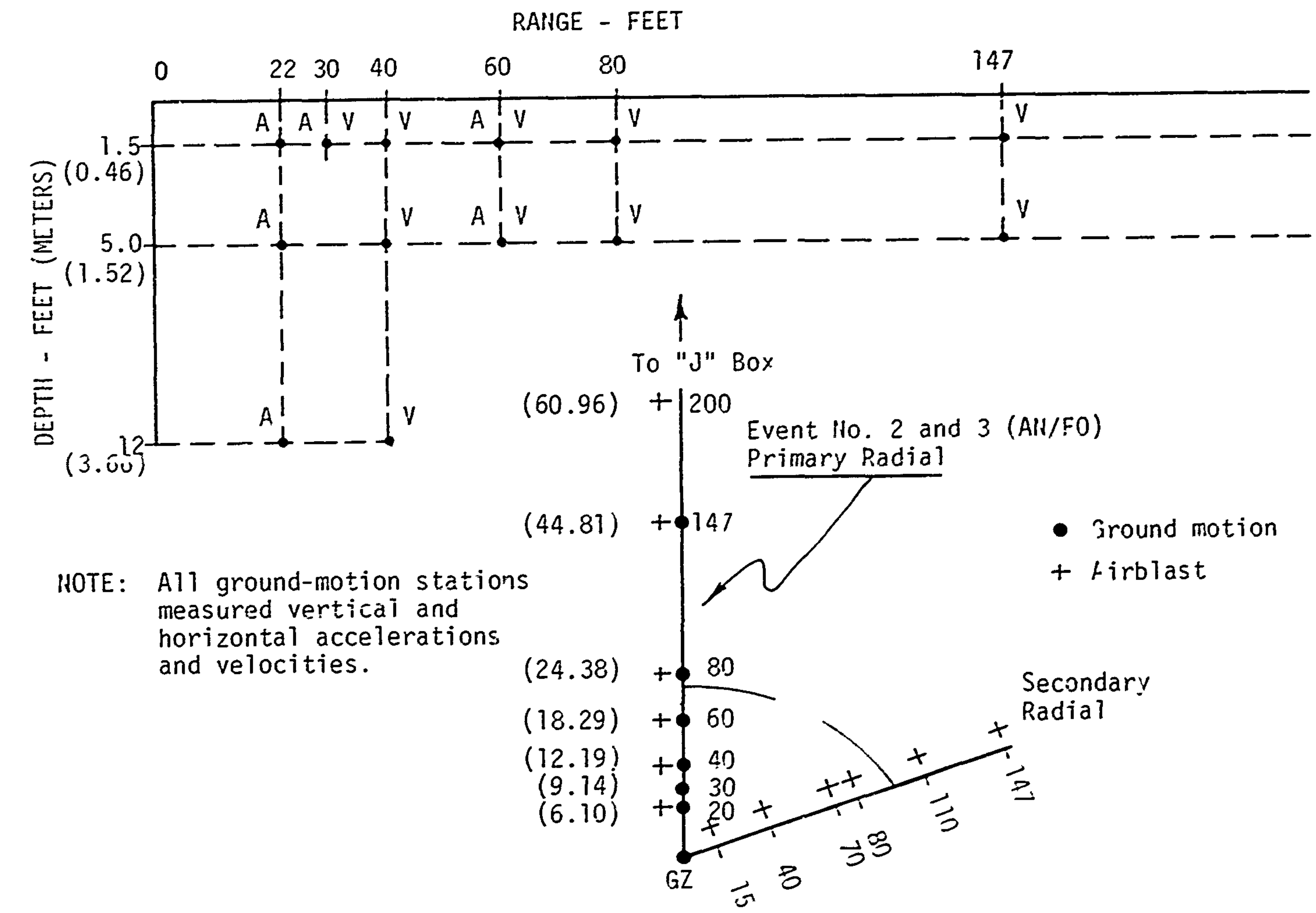


Figure 1-17. Pre-DICE THROW I, Events 2 and 3, ANFO Cylindrical Charges, Airblast and Ground-Motion Measurement Stations

(4) Event No. 4, 11,155 lbs (5059.82 kg) ANFO, Capped Cylinder with an L:D of 0.75:1, 31 July 1975.

The last event in this series used seven cylindrical boosters with two detonators in each with the exception of the top booster having only one. Six airblast measurements were made along each of two radials as shown in Figure 1-18.

Detonation velocity measurements were made on Events 2 and 3 (ANFO). (Refer to the photographs in Figure 1-19.) Rate sticks were placed within the charge on three booster radials. Each rate stick had seven pins equally spaced along the radials for a total of 21 measurements on each charge. (Event 3 had two additional pins placed at the booster locations not covered by rate sticks.) Each crater was surveyed by the CERF on four different radials for apparent crater determinations.

2. Denver Research Institute (DRI) - Project Officer: Mr. J. Wisotski

OBJECTIVES: This technical photography is required for the characterization of visual air-shock quality. Determinations will be made of the degree and extent of explosive jetting, of triple-point trajectory and qualification of surface-surge phenomena.

There were three camera stations monitoring each of the four events of Pre-DICE THROW I; two were remote and one was a manned station (refer to Figure 1-10). Power was provided to each station via motor-generator sets. The remote-stations readiness was determined visually by monitoring a light on top of each station. The technical photographic coverage included the use of the cameras as specified in Tables 1-3 and 1-4. Photographs of the remote and manned stations are shown in Figure 1-20.

3. U. S. Aerospace Audio Visual Services/U. S. Army Electronics Proving Ground (AAVS/EPG). Project Officers:
Mr. R. Spainhour (AAVS)
Maj. W. Scamahorn (EPG)

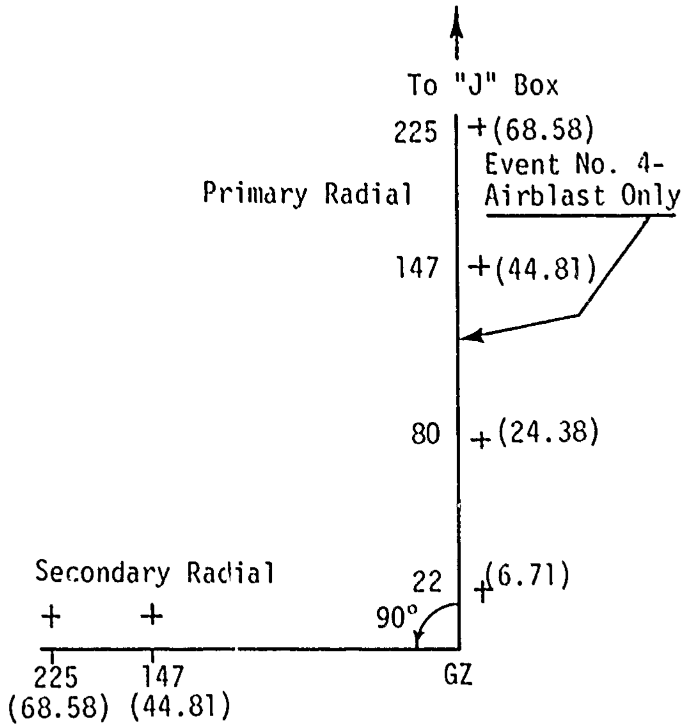


Figure 1-18. Pre-DICE THROW I, Event 4, ANFO Cylindrical Charge, Airblast Measurement Stations

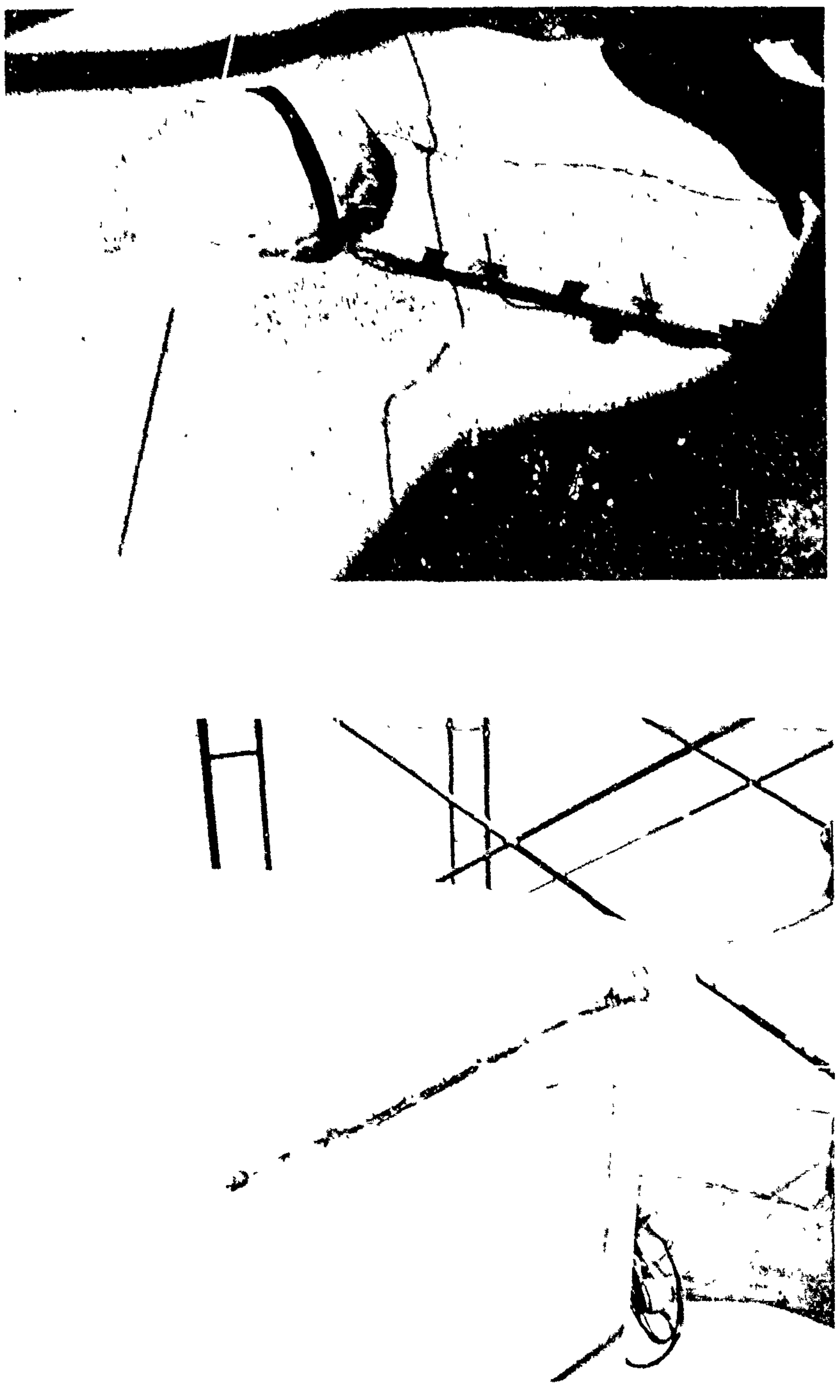


Figure 1-19. Detonation Velocity Measurement - Rate Stick Used on Pre-DICE THROW I

Table 1-3. DRI Cameras for Pre-DICE THROW I, Events 1, 2 and 3

Camera Type	Location	Framing Rate (frames/sec)	Lens	View
DB Milliken	Main	400	35mm	Charge Centered
Hycam, IR	Main	8,300	100mm	Charge Centered
Hycam, IR	Main	7,400	100mm	Charge Centered
Fastax	Main	4,800	100mm	Right of GZ
Nova	Main	6,900	100mm	Left of GZ
Dyna Fax	Main	25,000		Charge Centered
Dyna Fax	Main	25,000		Charge Centered
Solar Cell	Main	Scope Record		Charge Centered
Mod Py I	Main	Scope Record		Charge Centered
DB Milliken	Outpost #1	250	35mm	Charge Centered
Fastax	Outpost #1	4,300	100mm	Left of GZ
Fastax	Outpost #1	4,200	100mm	Right of GZ
DB Milliken	Outpost #2	250	35mm	Charge Centered
Fastax	Outpost #2	4,400	100mm	Left of GZ
Fastax	Outpost #2	4,000	100mm	Right of GZ
DB Milliken	D7	400	35mm	Charge Centered

NOTE: All film was 16mm.

Table 1-4. DRI Cameras for Pre-DICE THROW I, Event 4

Camera Type	Location	Framing Rate (frames/sec)	Lens	View
Locam	Main	495	35mm	Charge Centered
Hycam (1/4), IR	Main	31,090	75mm	Charge Centered
Hycam, IR	Main	3,420	100mm	Charge Centered
Fastax	Main	4,500	50mm	Right of GZ
Fastax	Main	4,180	100mm	Right of GZ
Fastax	Main	4,620	100mm	Left of GZ
Solar Cell	Main	Scope Record		Charge Centered
Mod Py I	Main	Scope Record		Charge Centered
Dyna Fax	Main	25,000		Charge Centered
Dyna Fax	Main	25,000		Charge Centered

NOTE: All film was 16mm.

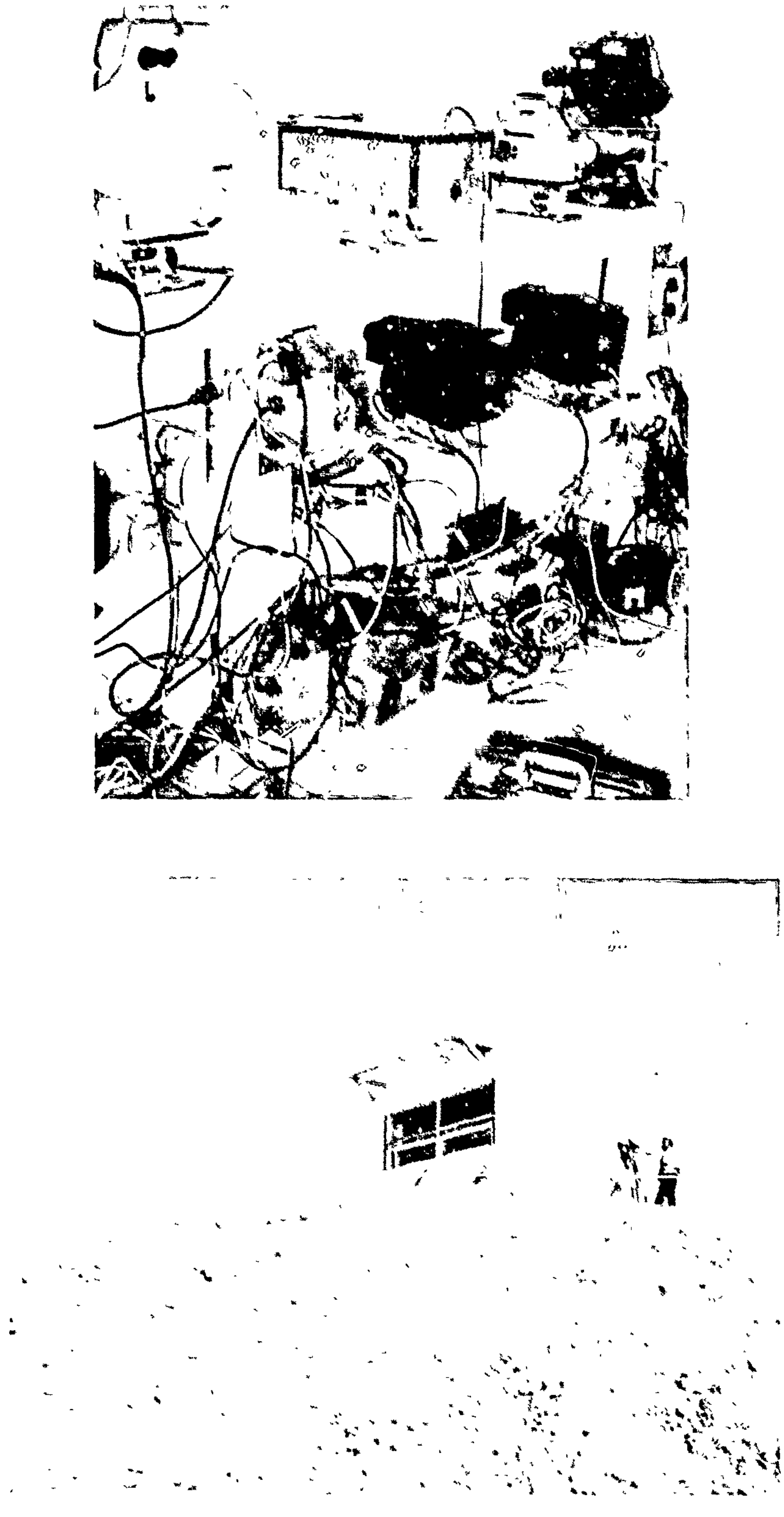


Figure 1-20. Camera Stations, Pre-DICE THROW I, Remote (Top Photo)

OBJECTIVES: Provide overhead technical photography for determining detonation characteristics and stereoscopic mapping.

An NC 47J aircraft with five different cameras on board was used on Events 2 and 3 to provide the above-mentioned technical photographic coverage. The cameras used were:

(1) 1 each 16mm @ 3,000 fps (914.40 mps)

(2) 1 each 16mm @ 500 fps (152.40 mps)

(3) 1 each 16mm @ 128 fps (39.01 mps)

(4) 1 each 70mm sequential @ 10-20 fps (3.05-6.10 mps)

(5) 1 each KC6A Stereoscopic Mapping Camera

The aircraft, staging from Kirtland Air Force Base, New Mexico, flew at an altitude of 10,000 ft (3,048.00m) above mean sea level with a flight path north to south along a vector 162.4 degrees from grid north. Radio communications with the aircraft were maintained via the WSMR net.

4. White Sands Missile Range (WSMR)

Project Officers: Mr. W. Brown, Mr. B. Galloway, Mr. D. Green, Mr. J. Martinez, Mr. A. Triller

OBJECTIVES: Provide construction support, documentary photography (still and movie) and to make pressure measurements to assess ARMTE instrumentation capability.

The construction support provided by WSMR included: clearing of the site area, making access roads, building camera mound stations, digging cable trenches, etc., as well as the necessary documentary photography, including still, motion and sequential pictures, using the cameras indicated in Tables 1-5 through 1-8, and Figure 1-21.

Pressure measurements were made on Events 1, 2 and 3.

5. EG&G, Inc. - Project Officer: Mr. R. Ward

OBJECTIVES: To provide cable coordination for DNA. Cable requirements for Pre-DICE THROW I were:

(1) 32,000 ft (9,753.60m) of 3-pair cable, #8777, not recovered.

(2) 8 each 5,000-ft (1,524-m) runs of 20-pair cable, recovered.

(3) 8,000 ft (2,438.4m) of RG 213, recovered.

(4) 30,000 ft (1,144m) of field wire, not recovered.

Table 1-5. WSMR Cameras for Pre-DICE THROW I, Event I

Camera Type	Location	Framing Rate (frames/sec)	Lens	Film	View
Photosonic 10-B	E0799	360	24 in.	70mm	Charge at Lower Right
Milliken	E0800	400	1 in.	16mm	Charge Centered
Nova, 1/4 Frame	E0801	25,000	20 in.	16mm	Charge Centered
Nova	E0802	7,000	1000mm	15mm	Charge Centered
Nova	E0803	5,000	20 in.	16mm	Charge Centered
Nova	E0804	5,000	375mm	16mm	Charge Centered

Table 1-6. WSMR Cameras for Pre-DICE THROW I, Event 2

Camera Type	Location	Framing Rate (frames/sec)	Lens	Film	View
Photosonic 10-B	0799	360	24 in.	70mm	Charge Centered
Photosonic 10-B	0807	360	24 in.	70mm	Charge Centered
Photosonic 10-B	0808	360	24 in.	70mm	Charge Centered
Milliken	0600	400	1 in.	16mm	Charge Centered
Milliken	0804	400	1 in.	15mm	Charge Centered
Milliken	0809	400	1 in.	16mm	Charge Centered
Nova	0801	40,000	6 in.	16mm	Charge Centered
Nova	0802	10,000	6 in.	16mm	Charge Centered
Nova	0803	20,000	20 in.	16mm	Charge Centered

Table 1-7. WSMR Cameras for Pre-DICE THROW I, Event 3

Camera Type	Location	Framing Rate (frames/sec)	Lens	Film	View
Photosonic 10-B	E0799	360	24 in.	70mm	Charge Centered
Photosonic 4-C	E0807	2,500	10 in.	35mm	Charge at Lower Right
Hycam, 1/4 Frame	E0800	40,000	6 in.	16mm	Charge Centered
Hycam, 1/2 Frame	E0804	20,000	6 in.	16mm	Charge Centered
Hycam	E0809	10,000	6 in.	16mm	Charge at Lower Left
Nova	E0801	10,000	6 in.	16mm	Charge at Lower Right
Nova	E0802	7,000	3 in.	16mm	Charge at Lower Left
Nova	E0803	5,000	3 in.	16mm	Charge at Lower Right

Table 1-8. WSMR Cameras for Pre-DICE THROW I, Event 4

Camera Type	Location*	Framing Rate (frames/sec)	Lens	Film	View
Photosonic 4-C	Site 1	2500	10 in.	35mm	Charge at Lower Left
Photosonic 4-C	Site 1	2500	6 in.	35mm	Charge at Lower Left
Photosonic 4-C	Site 1	2500	10 in.	35mm	Charge at Lower Right
Photosonic 4-C	Site 3	2500	10 in.	35mm	Charge at Lower Left
Photosonic 4-C	Site 3	2500	10 in.	35mm	Charge at Lower Right
Photosonic 10-B	Site 3	360	7 in.	70mm	Charge at Bottom Center
Photosonic 10-R	Site 4	50	10 in.	70mm	Charge at Bottom Center
Nova	Site 1	5000	3 in.	16mm	Charge at Lower Left
Nova	Site 3	5000	4 in.	16mm	Charge Centered

*Site 1 is northwest of DICE THROW mound
Site 3 is southwest of DICE THROW mound
Site 4 is at D-7

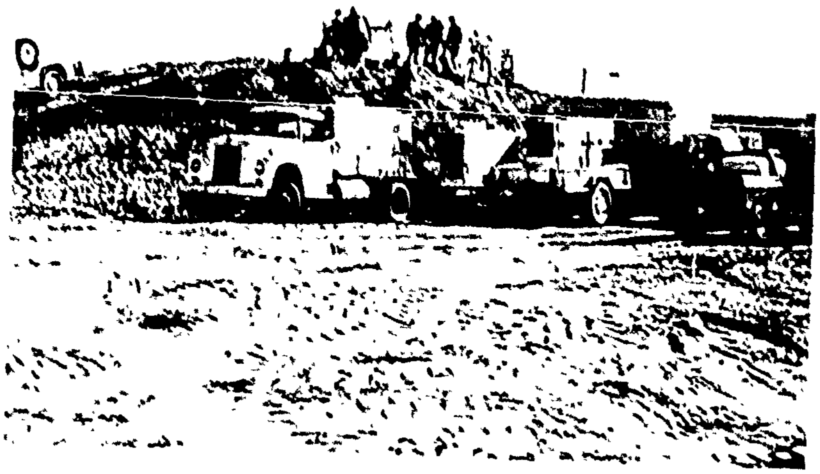


Figure 1-21. WSMR Photograph Station on Pre-DICE THROW I

CHAPTER II

PRE-DICE THROW II TEST EXECUTION REPORT

INTRODUCTION

The Pre-DICE THROW II program conducted near the Queen 15 site on the White Sands Missile Range (WSMR) consisted of three separate events: Cylindrical In Situ Test (CIST), 100-ton (90.7-metric-ton) TNT surface-tangent sphere and 120-ton (108.9-metric-ton) ANFO right-circular cylinder, base-tangent to surface, with hemispherical top. This fourth phase of the DICE THROW program was initially designed as a calibration series for the main event; however, because of the amount of experimental participation on the TNT event (required for cratering, airblast and ground-shock data to calibrate the specific geology) the word calibration was dropped. The CIST and ANFO events kept their calibration status.

The safety requirements for Pre-DICE THROW II are located in the following Safety Standard Operating Procedures for Pre-DICE THROW Explosive Operations:

1. SOP 224-14-75, 7 July 1975; Operation No. 5, Cylindrical In Situ Test. Arming and Detonation of Explosives.
2. SOP 224-14-75, 31 July 1975; Operation No. 8, Off-Loading and Stacking Explosives, 100-Ton (90.7-Metric-Ton) TNT Test; Operation No. 9, 100-Ton (90.7-Metric-Ton) TNT Stacking Emergency Procedures; Operation No. 10, 7 August 1975, Firing Hook-Up and Detonation (100-Ton (90.7-Metric-Ton) TNT); with Appendix I, High Voltage Firing System Description, Appendix II, Countdown for Pre-DICE THROW II, 100-Ton (90.7-Metric-Ton) TNT Event and Memorandum dated 11 August 1975 requesting changes to SOP 224-14-75, Operation 10, from LCDR E. W. Edgerton to Commander, WSMR, Attention SF.
3. SOP 224-14-75, 8 September 1975; Operation No. 9, 100-Ton (90.7-Metric-Ton) TNT Stacking Emergency Procedures with letter from Mr. H. F. Lozano, Chief, Warheads Branch, to SF

requesting changes to SOP 224-14-75 Operation No. 9; Operation No. 11, Final Assembly of Booster-Initiation System (BIS) (120-Ton (108.9-Metric Ton) ANFO Event); Operation No. 12, Main Booster Assembly (MBA) Emplacement; Operation No. 13, Main Charge Construction (120-Ton (108.9-Metric Ton) ANFO Event); Operation No. 14, BIS Emplacement, Firing System Hook-Up and Detonation (120-Ton (108.9-Metric Ton) ANFO).

4. SOP-224-36-75, 8 August 1975; Laser Operation for Pre-DICE THROW at WSMR.
5. SOP 224-41-75, 11 September 1975; Laser Operations for Pre-DICE THROW at WSMR.

Survey information pertaining to GZ 5 (TNT event) and GZ 6 (ANFO event) are found in Defense Mapping Agency Geodetic Support Activity Topographic Center, White Sands Missile Range, Survey Report No. 505-75, 12 August 1975; Survey Report No. 639-75, 1 October 1975; and Survey Report No. 637-75, 1 October 1975. Survey Report No. 107-75 locates the CIST area and instrumentation van.

The ground zero locations for this series of tests were located approximately 5,000 ft (1,524 m) southeast of the charge configuration testing area (refer to Figure 2.1). The ground-water level in the GZ 5 and GZ 6 area is approximately 7 ft (2.13 m) as opposed to approximately 50 ft (15.24 m) in the GZ 1 through GZ 4 area. This shallow water table was one of the requirements for the TNT test main experimenter (MX experiments). The major objectives for each of these events will be discussed in their respective test descriptions. The Pre-DICE THROW II Summary Schedule is shown in Figure 2.2.

Pre-DICE THROW II FCTMOT Staff

LCDR Bill Edgerton - Test Group Director
Capt. Tom Edwards - Technical Director
Capt. Ernie Jaskolski - Test Group Engineer
Maj. Rich Palaschak - Program Coordinator
LCDR J. D. Strode - Program Coordinator/Deputy Test Group Director

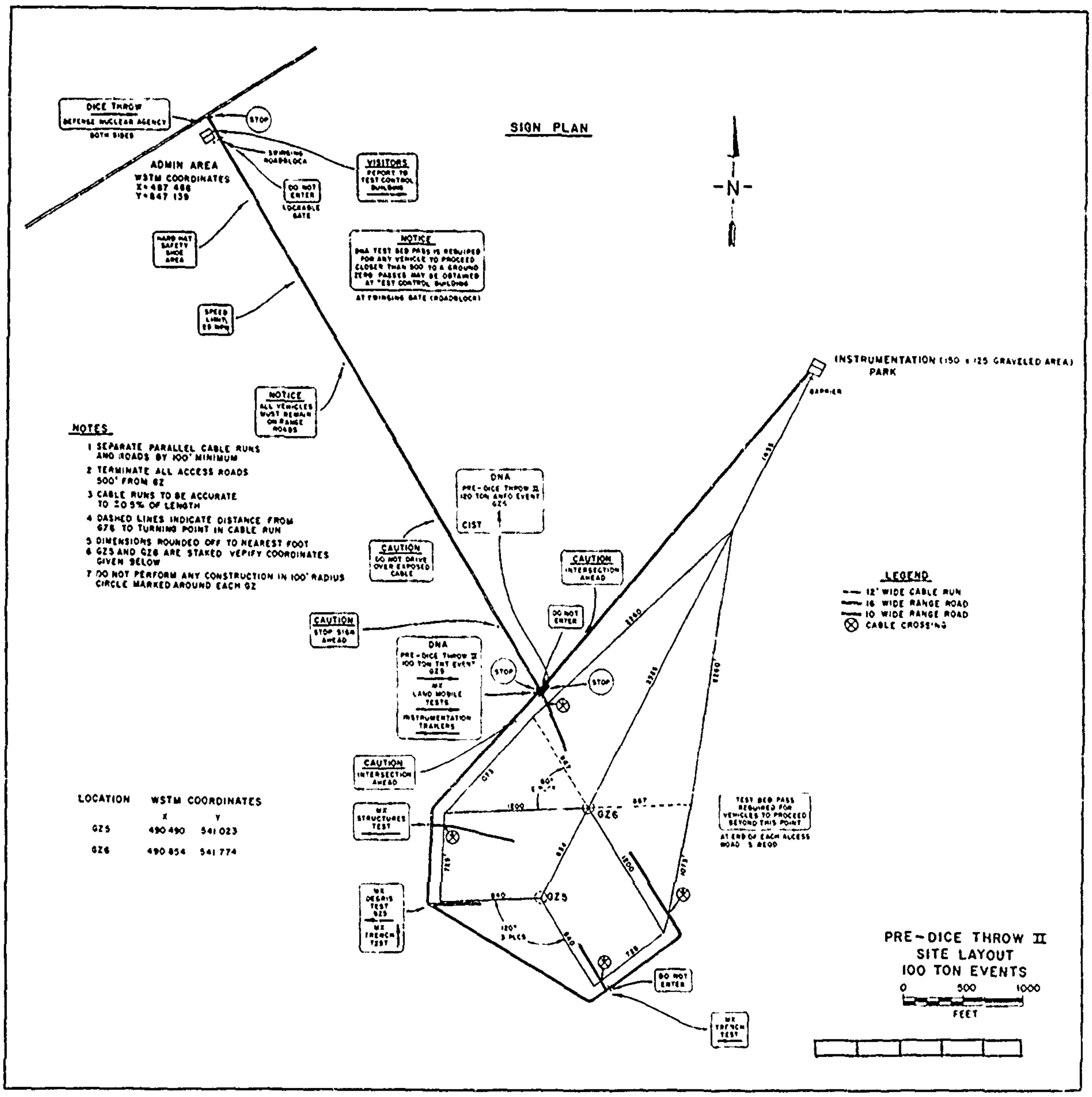


Figure 2-1. Pre-DICE THROW II Testing Area

PRE-DICE THROW II SU

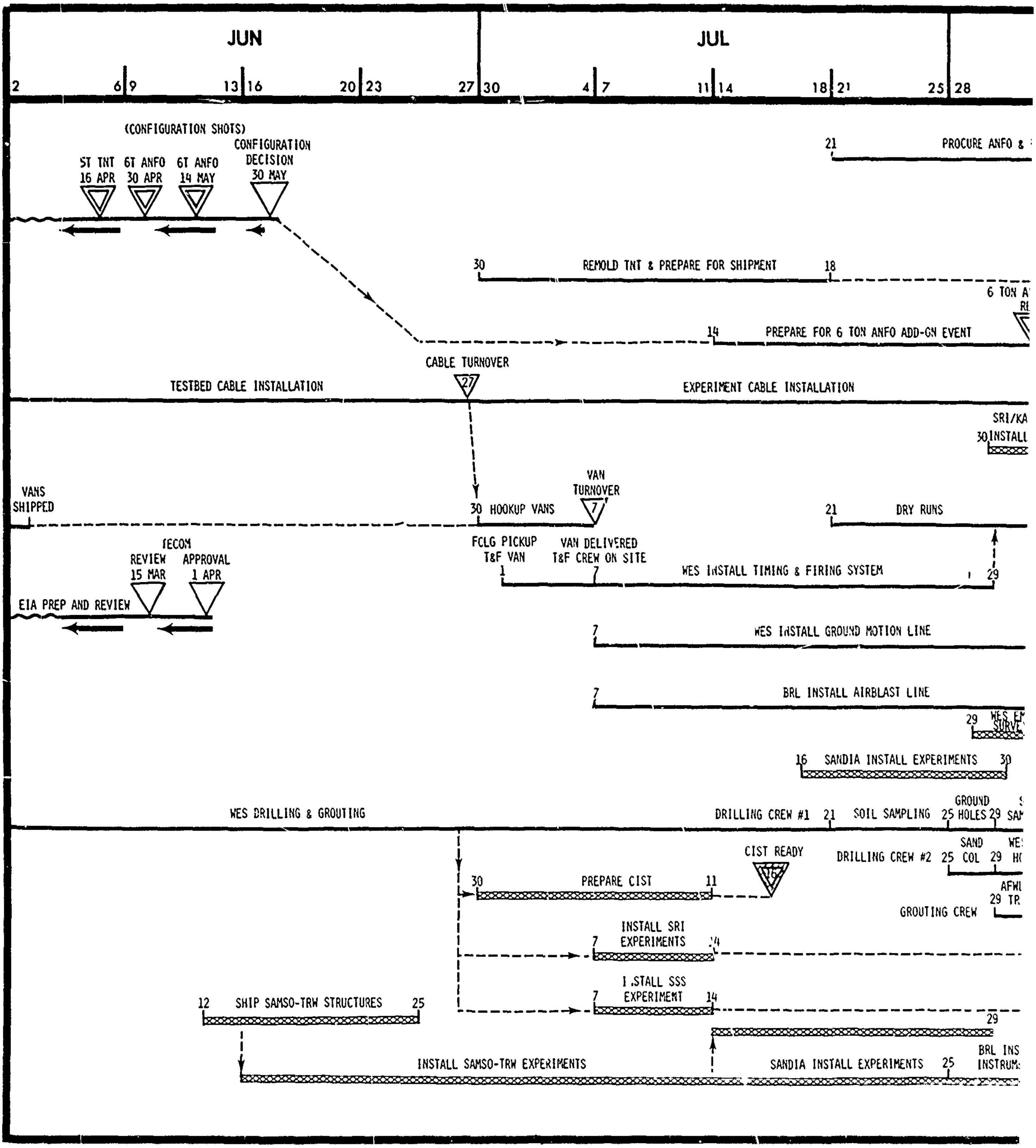
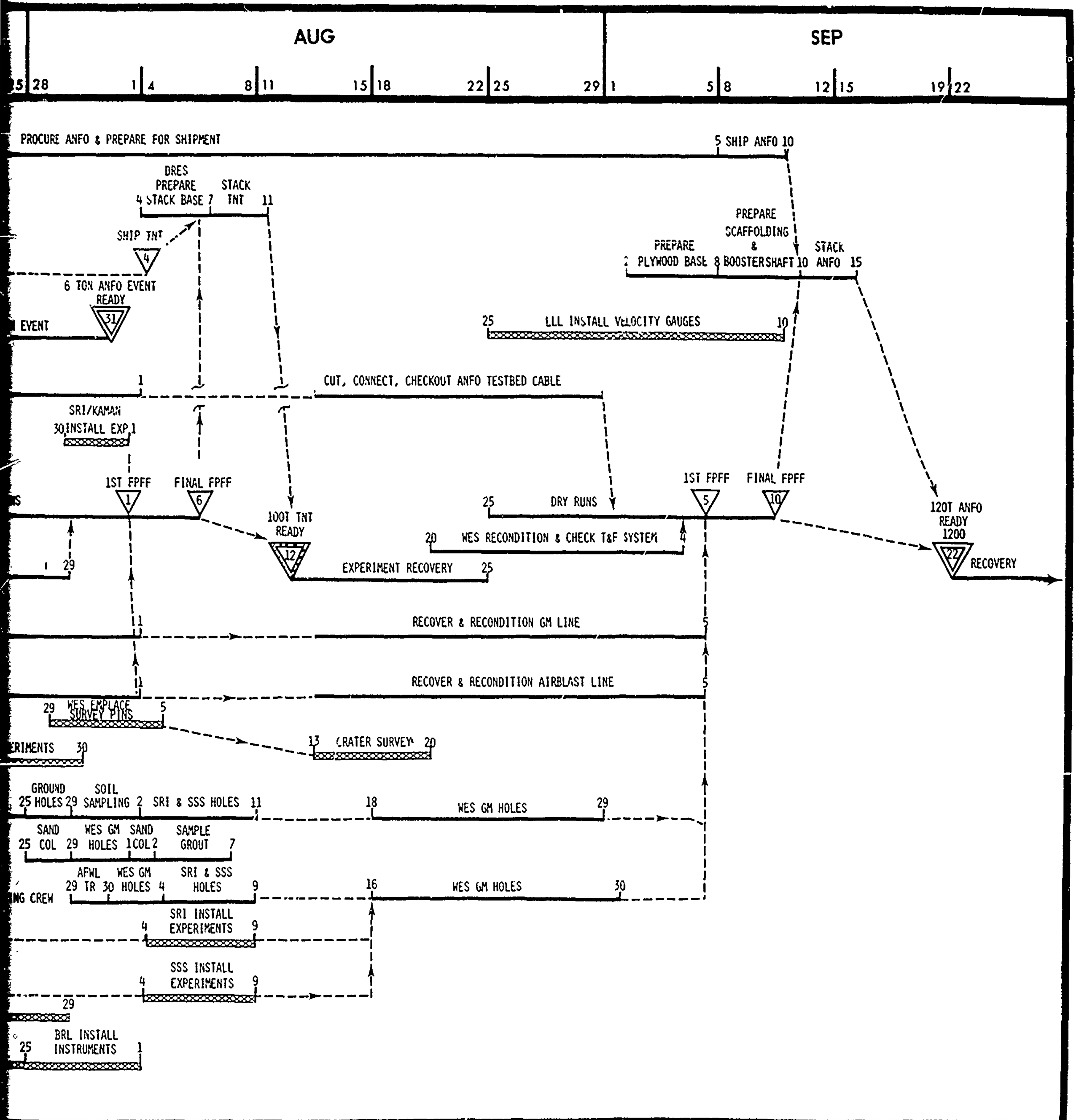


Figure 2-2. Pre-DICE THROW II Summary Schedule

SUMMARY SCHEDULE

FCTD-A
As Built 23 OCT 75



2

Mr. Lou Stefani - Program Analyst

Mr. Noel Gantick - Instrumentation Engineer

Mr. J‹ e Sneed - Safety Engineer

Experimenters and Support Agencies

1. Air Force Weapons Laboratory (AFWL)
2. Ballistic Research Laboratory (BRL)
3. Defense Research Establishment Suffield (DRES)
4. EG&G, Inc.
5. U. S. Army Electronics Proving Ground (EPG) and U. S. Air Force Aerospace Audio Visual Services (AAVS)
6. Lawrence Livermore Laboratory (LLL)
7. Naval Surface Weapons Center (NSWC)
8. Naval Weapons Evaluation Facility (NWEF)
9. Strategic Air Command (SAC)
10. Space and Missile Systems Organization (SAMSO) and TRW Systems Group (TRW)
11. Sandia Laboratory Albuquerque (SLA)
12. Stanford Research Institute (SRI)
13. Kaman Sciences Corporation
14. Systems, Science and Software, Inc. (SSS)
15. Denver Research Institute (DRI)
16. U. S. Army Engineer Waterways Experiment Station (WES)
17. White Sands Missile Range (WSMR)
18. Hughes Aircraft Corp./U. S. Air Force Avionics Laboratory
19. Civil Engineering Research Facility (CERF)
20. The Ralph M. Parsons Company
21. United States Geological Survey (USGS)
22. Environmental Research Institute of Michigan (ERIM)
23. Southern Methodist University (SMU)
24. Ken O'Brien and Associates (KOA)
25. U. S. Army Missile Command (ARMCOM)
26. General Elect' ic—TEMPO

Charge Descriptions

1. CIST Construction Details

Figure 2-3 are photographs of the CIST assembly operations. Refer to Figure 2-1 for the CIST location with respect to GZ 5 and GZ 6. The CIST required a cased hole (with steel liner) 47 ft (14.3 m) deep and 28 in. (71.1 cm) in diameter to contain the explosive (AFWL hole designation L01). The explosive used was 205 lbs (92.99 kg) of 400-grain (25.92 gram) PETN primacord with a weight distribution of 5 lbs (2.27 kg) per foot. The total depth of the charge from the ground surface was 41.3 ft (12.59 m). The primacord was strung on racks (Figure 2-4) which were hooked together as shown in Figure 2-5. Figure 2-6 depicts the detonator/booster assembly.

2. 100-Ton TNT Surface-Tangent Sphere (GZ 5) - Construction Details

A photograph of the completed TNT sphere is shown in Figure 2-7. The charge, with a radius of 7.87 ft (2.40 m), was placed on a base made of 3 layers of 3/4-in. (1.91 cm) plywood 18 ft (5.49 m) in diameter. The lower hemisphere was supported with polystyrene blocks that were cut to conform to the outer surface of the TNT. These polystyrene blocks were pre-cut and marked according to TNT layer prior to stacking. Each layer of TNT was sprayed with an antistatic solution (Anti-Static Compound "Statico," Regal Supply and Chemical Co. of El Paso).

The charge was designed by the Defence Research Establishment Suffield (DRES), Ralston, Alberta, Canada. Details pertaining to the stacking plan, base and styrofoam blocks are located in the DRES Technical Support Plan. The booster was a 16-in. (4.64-cm)-diameter sphere of Tetryl weighing 123 lbs (55.79 kg) and was placed in the center of the TNT sphere during the stacking operation. Two aluminum tubes were also placed within the stack for access to the booster after the charge buildup (two detonators, X-128, inserted into the booster during the arming process). Ionization probes were placed along 13 radials within the charge to determine detonation velocity and symmetry of detonation. Photographs indicating various stages in the stacking operation are shown in Figure 2-8.

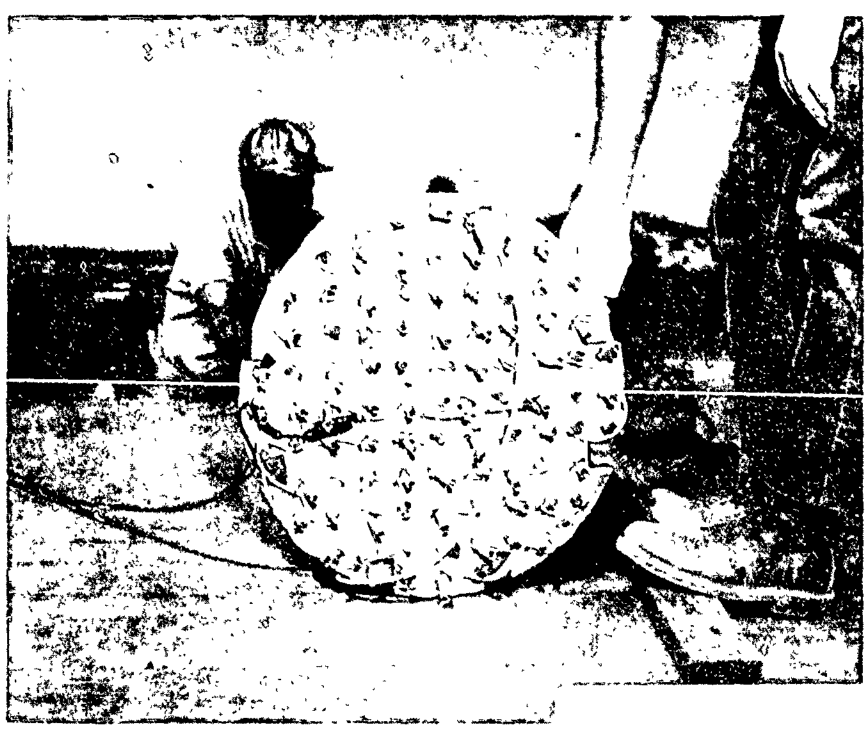


Figure 2-3. CIST Assembly Operations,
Pre-DICE THROW II

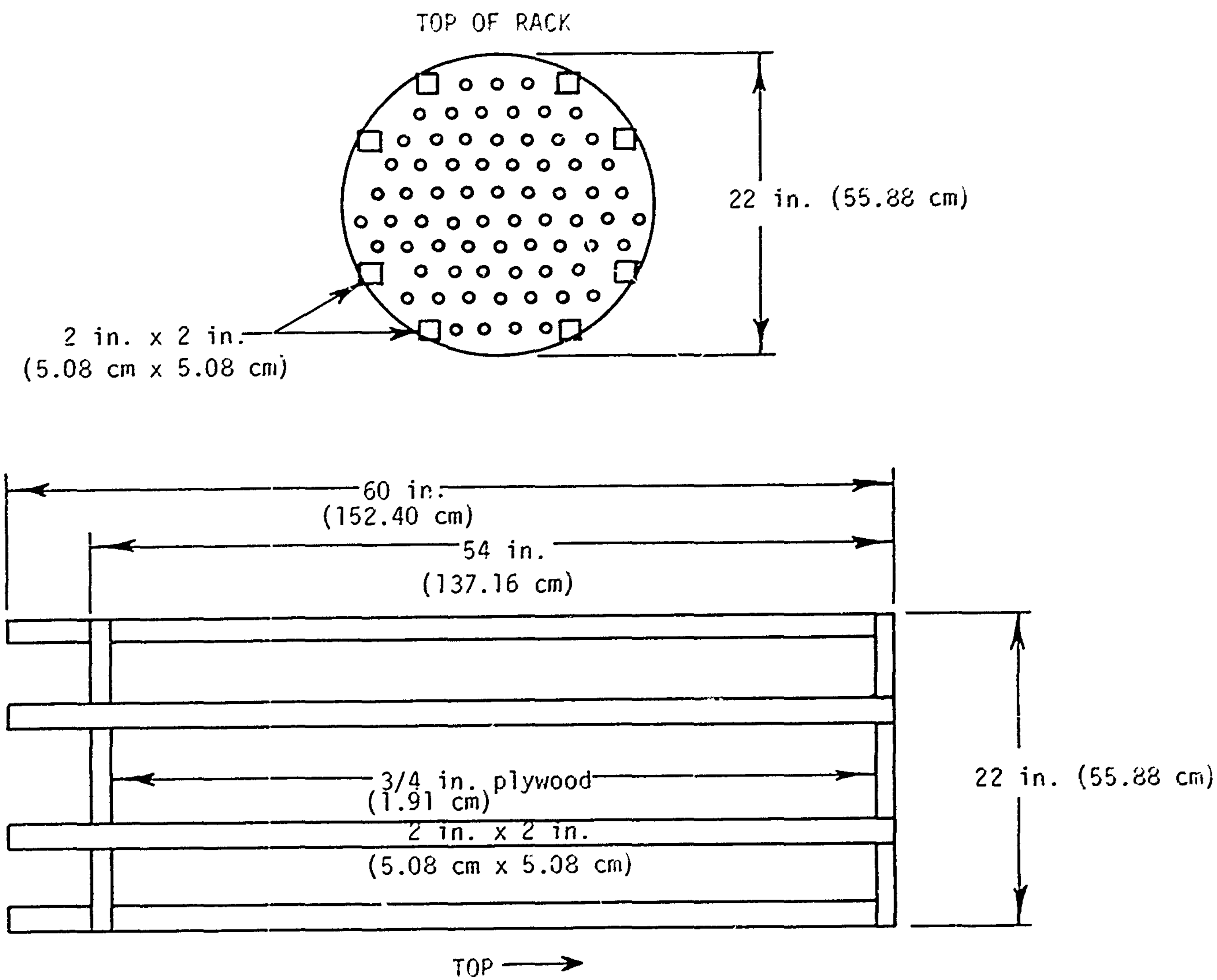


Figure 2-4. AFWL CIST Explosive Rack Construction, Pre-DICE THROW II

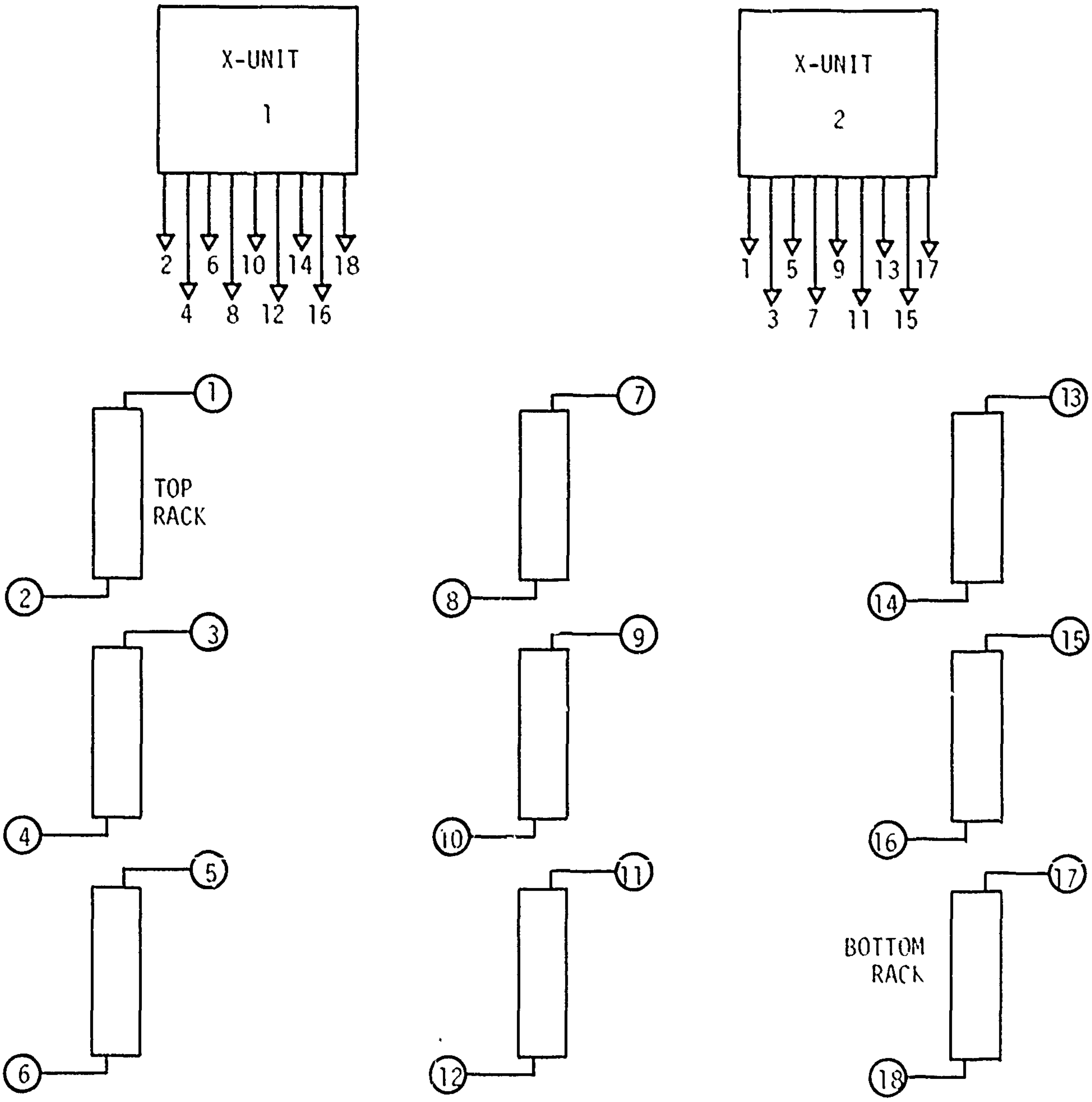
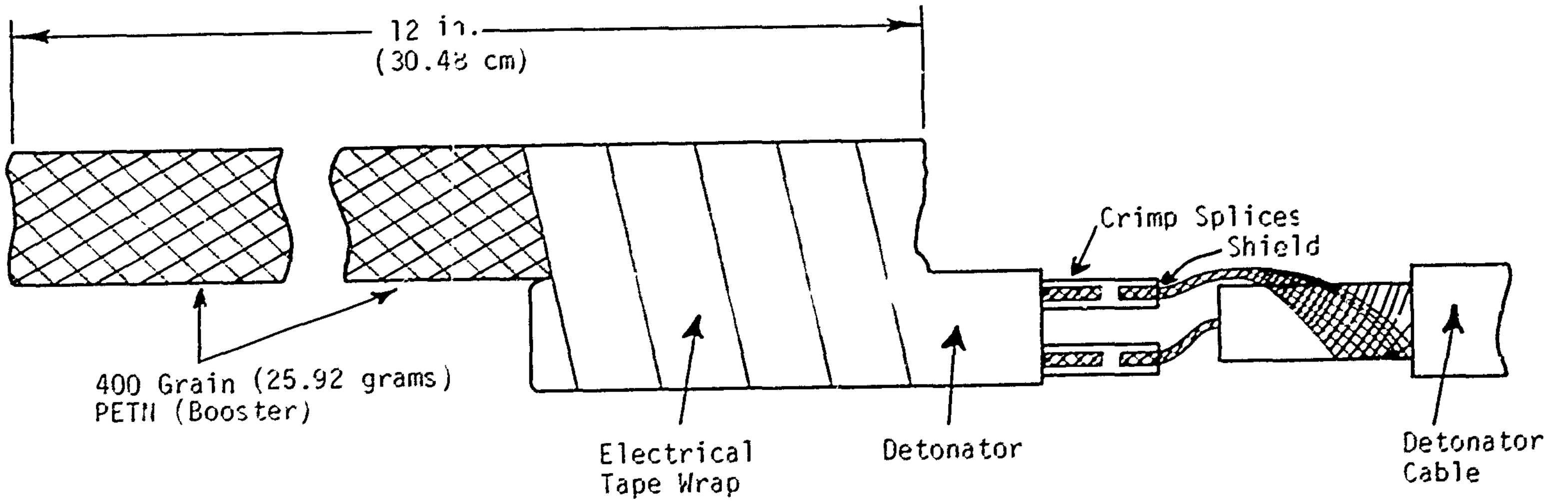


Figure 2-5. AFWL CIST Explosive Rack Hook-Up, Pre-DICE THROW II



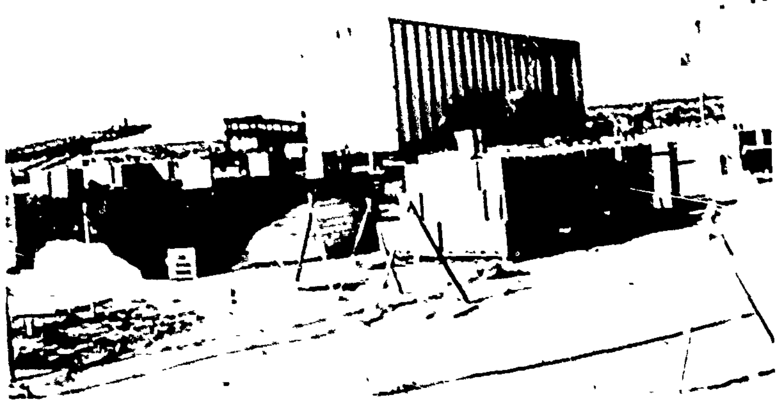
NOTE: Detonator and detonator cable splice insulated with AMP seal and taped with electrical tape.

Figure 2-6. CIST Detonator and Booster Assembly, Pre-DICE THROW II

Figure 2-7. Completed 100-Ton (90.7-Metric Ton) TNT Surface-Tangent Sphere, Pre-DICE THROW II

Lightning rods were equally spaced around the charge at four locations, 30 ft (9.14 m) from charge center. These rods were 30 ft (9.14 m) high and hooked to ground cables as indicated in the Technical Support Plan, Appendix D. An electrical potential-measuring device was also placed in the area to monitor the potential gradient in the area. Floodlights were used to illuminate the GZ area during the night stacking shifts.

The TNT blocks were procured from three places: DRES - 58 tons (52.6 metric tons); Iowa Ammunition Plant, Burlington, Iowa - 30 tons (27.22 metric tons); and Pueblo Army Depot, Pueblo (Avondale), Colorado - 20 tons (18.14 metric tons). The TNT blocks from the DRES and Pueblo locations had already been cast into 12x12x4-in. (30.5x 30.5x10.2-cm) blocks. The Iowa shipment had to be manufactured in



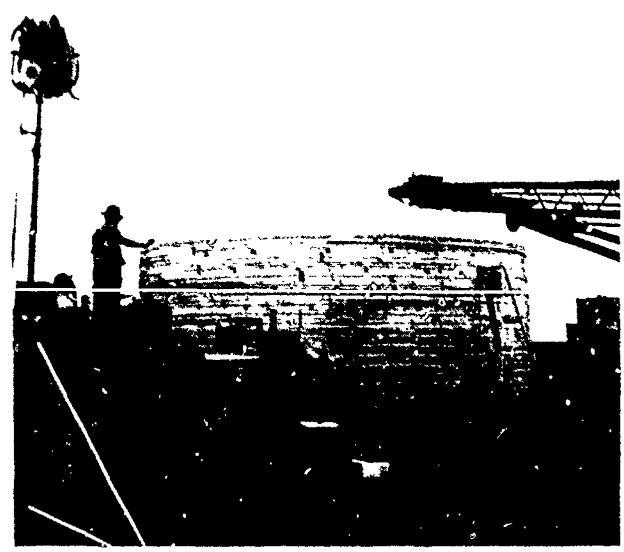


Figure 2-8. 100-Ton (90.7-Metric-Ton) TNT Stack - After One-Day Stacking (Top Photo), After Two-Day Stacking (Bottom Photo), Pre-DICE THROW II

cast blocks, with production starting 30 June 1975. The production was handled by Mason and Hanger, Silas Mason Company, Inc., the contractor who operates the plant for the Army.

The as-built charge weight, excluding the booster, was 199,978.6 lbs (90,708.8 kg) of TNT. Table 2-1 indicates the assortment and quantities of TNT blocks received at WSMR.

Table 2-1. 100-Ton (90.7-Metric-Ton) TNT Summary Data Sheet for Explosives Received for Pre-DICE THROW II, Event 1

(CANADIAN) DRES EXPLOSIVE RECEIVED			
Truck No.	No. Boxes		No. Blocks
1. (B/L K5584205)	638 503 133		1006 Whole 353 Partial 2 Boosters
2. (B/L K5584204)	600		1200 Whole
3. (B/L K5584206)	579		1158 Whole
		TOTALS	3364 Whole 353 Partial
USA EXPLOSIVES RECEIVED			
4. (B/L K8551440)	434		868 Whole
5. (B/L K8415246)	588		1176 Whole
6. (B/L K8551439)	504		1008 Whole
		TOTALS	3052 Whole
NOTE: For additional information see Canadian General Electric Company Limited letter of 26 August 1975 signed by Mr. A. P. R. Lambert.			

3. 120-Ton (108.9-Metric-Ton) ANFO (GZ-6)

The charge design, as shown in Figure 2-9, was a right-circular cylinder, base-tangent to the ground surface, hemispherical top, with a multiple detonating system. The charge was constructed from pre-mixed bagged ammonium nitrate and diesel fuel, which is a commercial blasting agent composed of 94.5 percent (by weight) ammonium nitrate and 5.5 percent Number 2 diesel fuel (ANFO). The length to diameter (L to D) of the cylindrical section was 0.75 to 1.00 (refer to Figure 2-10).

The ANFO was purchased from Bud Walter, Inc. of Estancia, New Mexico. It was pre-mixed and bagged at the plant prior to its delivery by truck to the WSMR Queen 15 site.

The Naval Surface Weapons Center (NSWC) had the following responsibilities:

(1) Design ANFO stack

(2) Design, fabricate and emplace initiation system

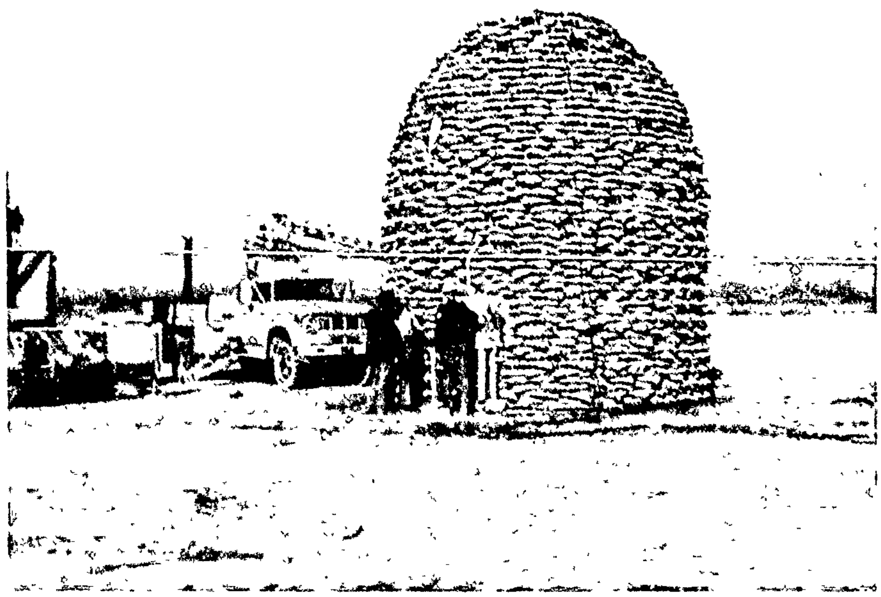


Figure 2-9. Completed 120-Ton (108.9-Metric-Ton) ANFO Charge, Pre-DICE THROW II

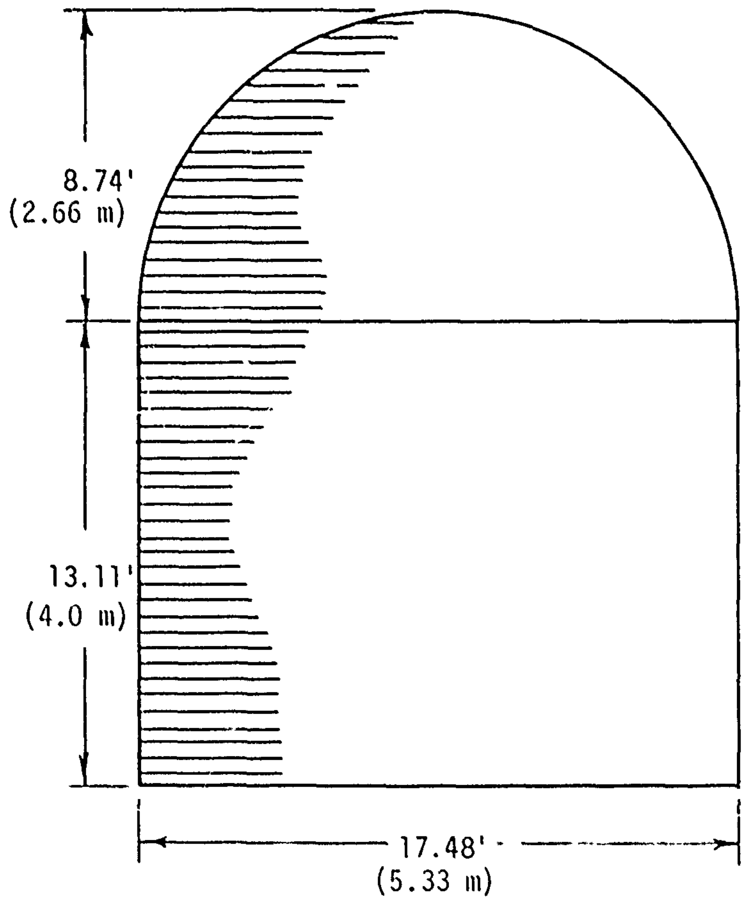


Figure 2-10. ANFO Charge Design, Pre-DICE THROW II

(3) Supervise charge construction

(4) Monitor fuel oil content and particle-size distribution of ANFO in charge, and

(5) Monitor internal temperature of charge up to time of detonation.

(a) Boostering and Initiation System. The boostering and initiation system was designed as a two-part system in order to meet safety requirements as outlined in SOP 224-14-75. The system consisted of a booster column containing 75/25 Octol (a very insensitive explosive) called the Main Booster Assembly (MBA), and an arming column containing pentolite, detonators and cabling called the Booster Initiation System (BIS). During charge construction, only the MBA was in place. At arming time, the BIS was lowered into the MBA.

The MBA consisted of the following: A piece of 5-in. (12.70-cm)-diameter (I.D.), 5.5-in. (13.97-cm)-diameter (O.D.), Poly-vinyl-Chloride (PVC) pipe, 20 ft (6.10 m) long, around which were placed seven discs of Octol, as shown in Figure 2-11. Each disc of Octol was 12 in. (30.48 cm) in diameter, 5 in. (12.70 cm) high and weighed approximately 29 lbs (13.15 kg). The discs were held in place with PVC flanges, cemented to both the pipe and to the Octol. Surrounding the Octol was a cardboard construction tube [1/4-in. (0.64-cm) wall thickness], 12 in. (30.48 cm) in diameter (I.D.), 20 ft (6.10 m) long. Figure 2-12 shows a photograph taken during the placement of the MBA.

The BIS consisted of the following: A 4.5-in. (11.43-cm)-diameter (O.D.), 4.0-in. (10.16-cm)-diameter (I.D.), piece of PVC pipe 22 ft (6.71 m) long. Into this pipe were placed seven pentolite discs, each weighing approximately 2 lbs (0.91 kg), as is shown in the assembly sketch, Figure 2-13. Refer also to the photos in Figure 2-14. Each pentolite disc was equipped with two exploding bridge-wire detonators, type RP-1, manufactured by Reynolds Industries. The seven detonators on the upward sides of the pentolite discs were considered the primary system, with the seven on the bottom as a back-up

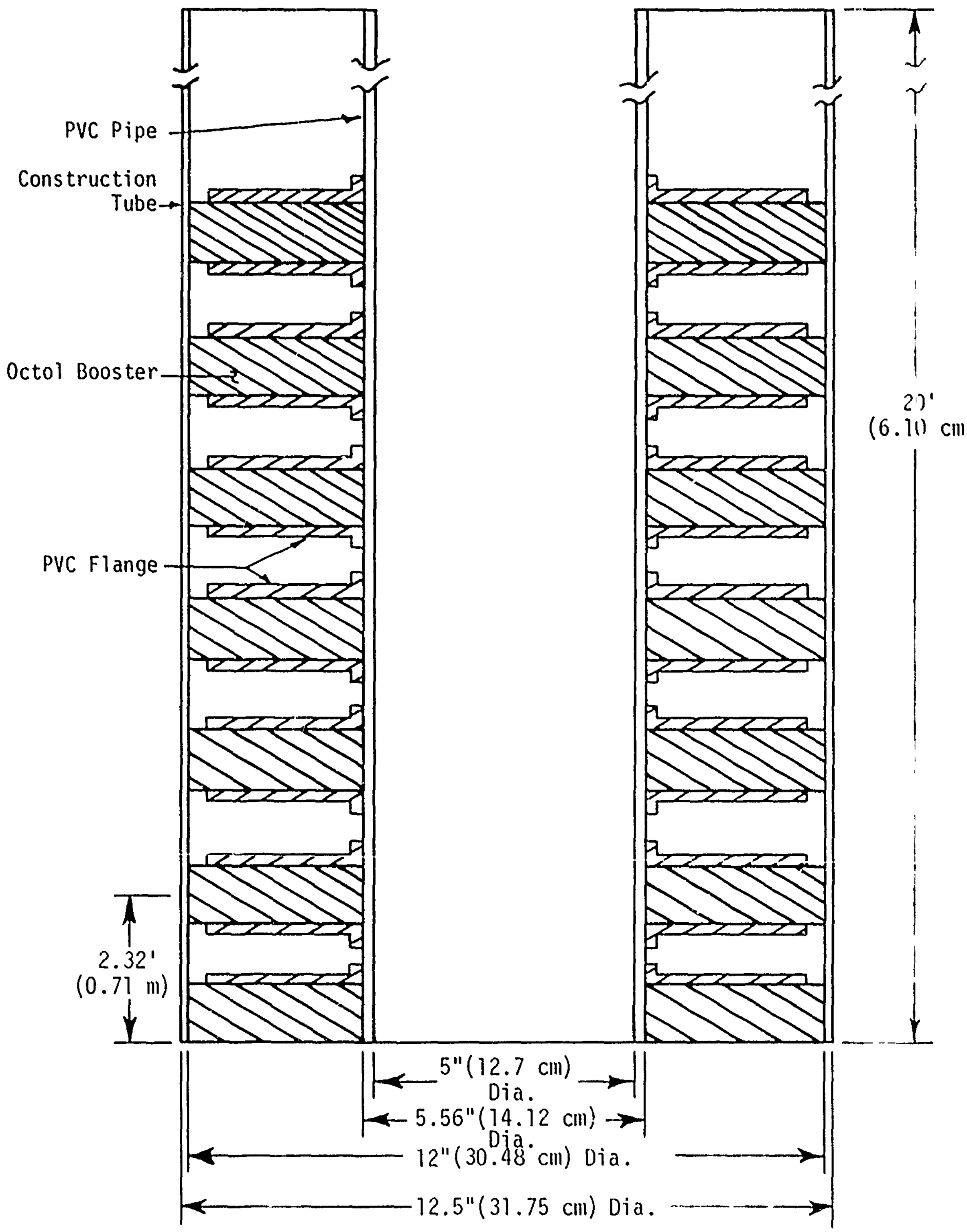
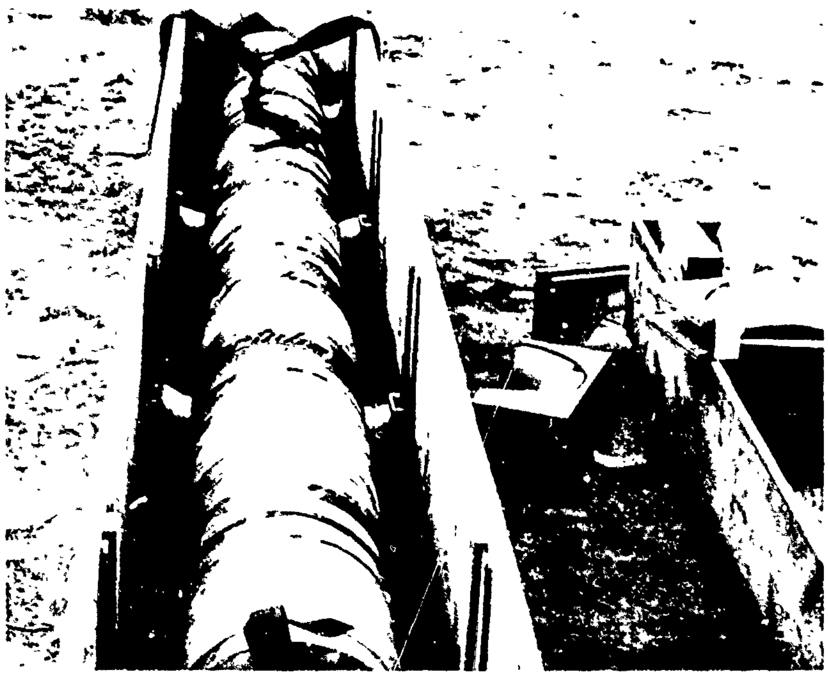


Figure 2-11. Main Booster Assembly (MBA), Pre-DICE THROW II



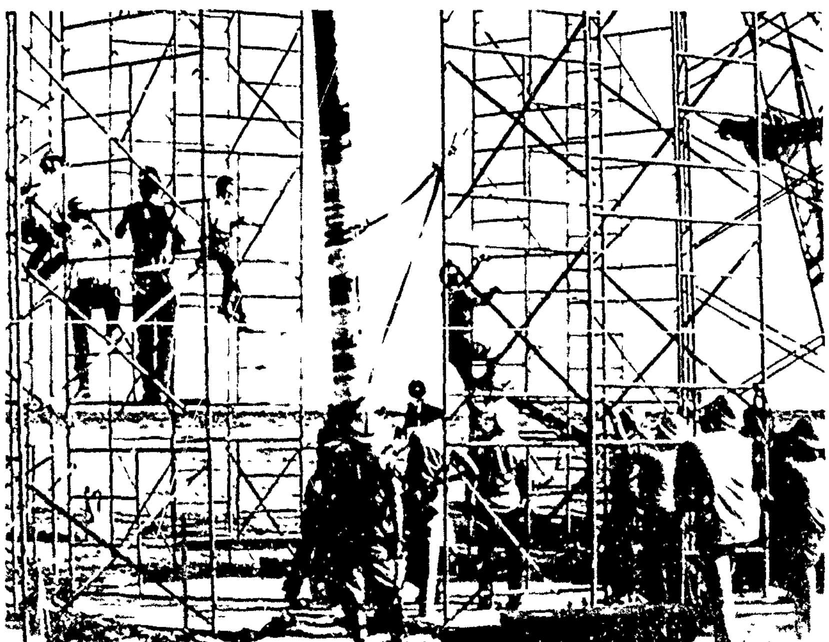


Figure 2-12. Photographs of the MBA Prior To and During Placement on Pre-DICE THROW II

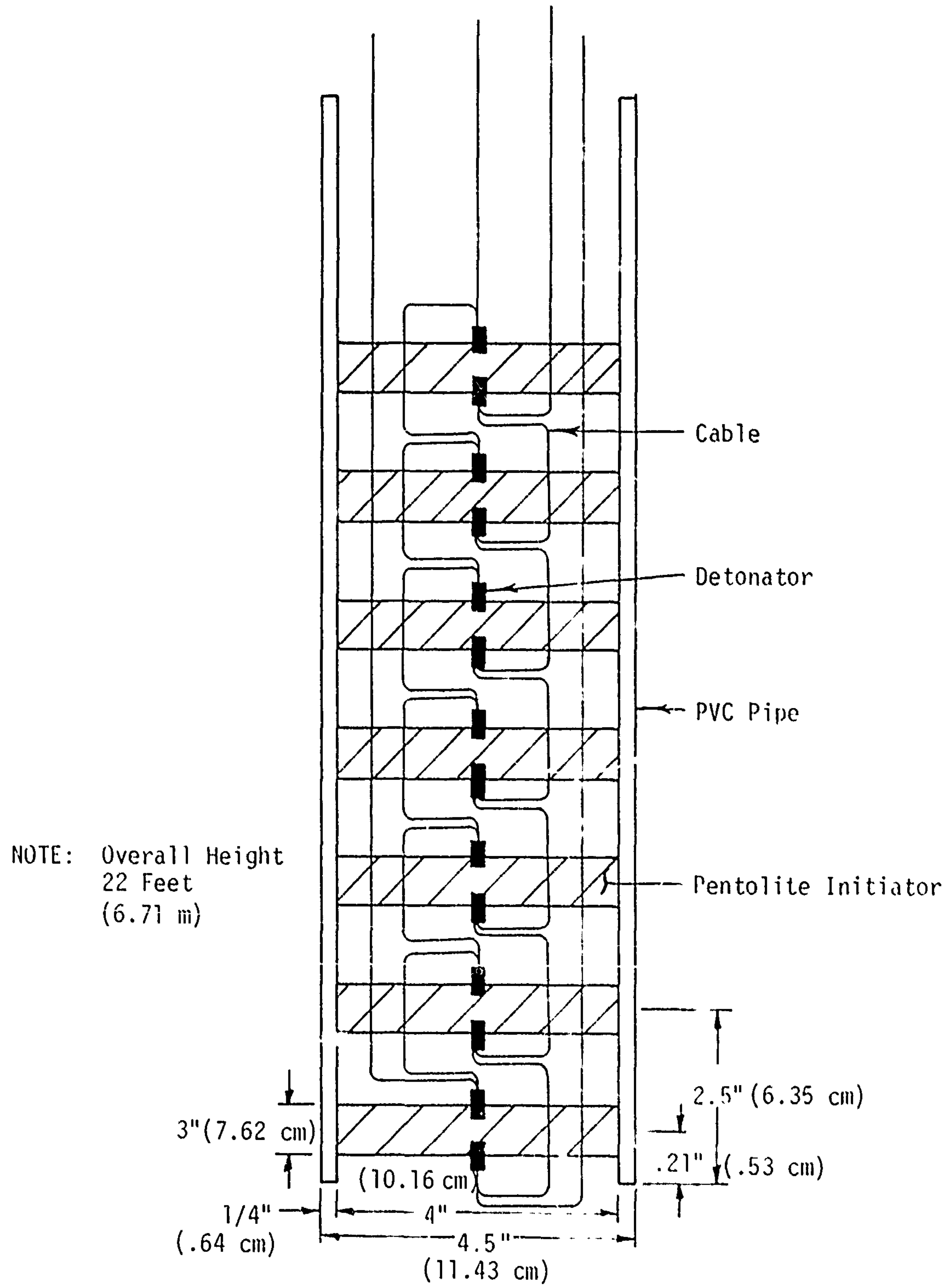


Figure 2-13. 120-Ton ANFO Booster Initiation System (BIS), Pre-DICE THROW II

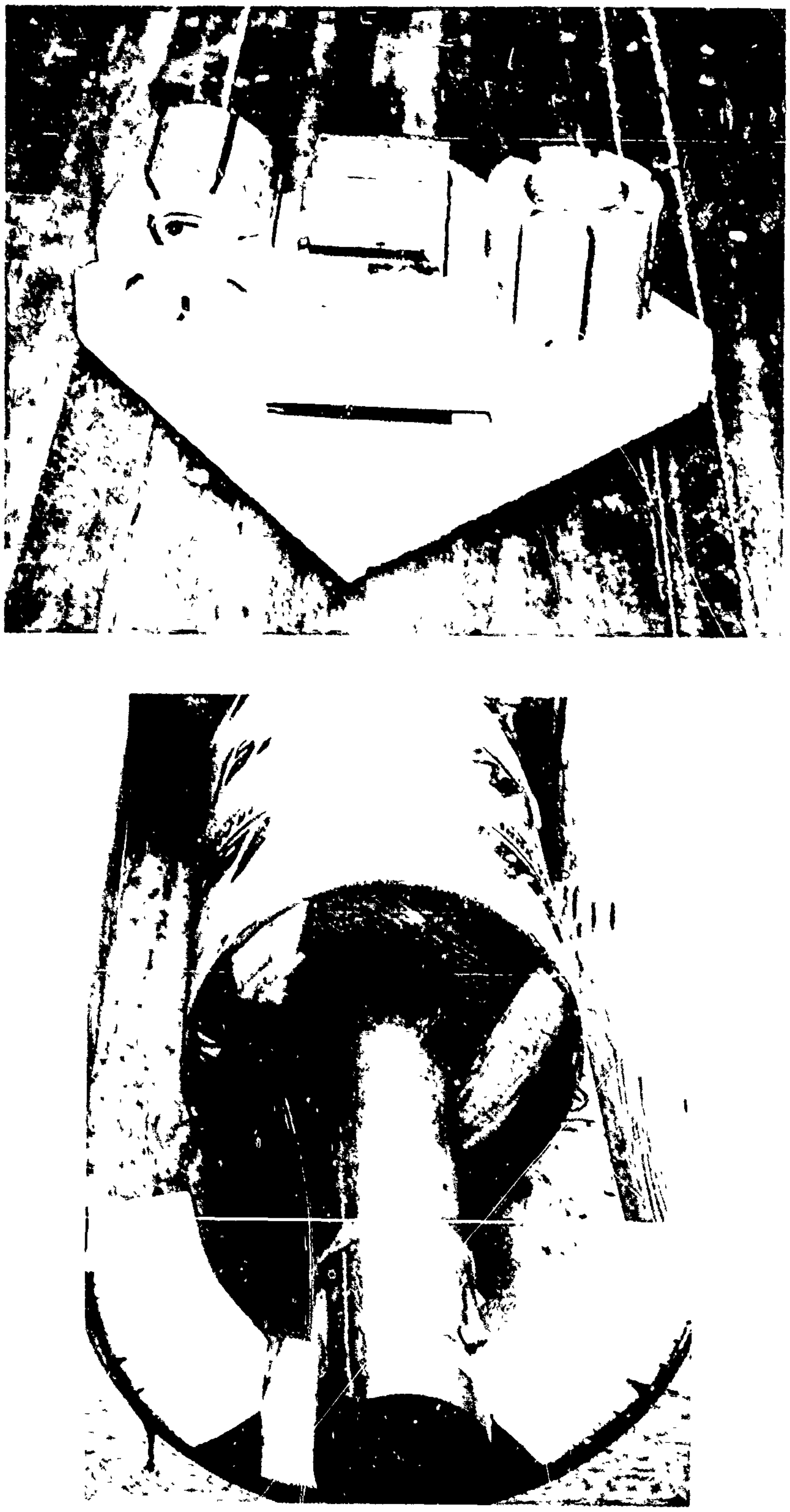


Figure 2-14. Pentolite Discs (Top Photo), Dummy BIS Inserted Into MBA (Bottom Photo), Pre-DICE THROW II

system. Each system of seven detonators was connected in series, using Reynolds high-voltage cable, and fired by its own firing supply.

In the armed position, each pentolite disc was opposite an Octol disc. The weights of the Octol and Pentolite in the BIS/MBA are presented in Table 2-2.

(b) Construction Details. Construction commenced on Wednesday, 10 September 1975, with 40 tons (36.3 metric tons) of ANFO being loaded. At this point, the charge was covered with a 6-mil plastic cover and stacking operations were suspended for the day. Rains and high winds prevented further operations until Saturday, 13 September. Upon removing the cover from the charge, it was discovered that a portion of the stack had collapsed (see Figure 2-15). The cause of the collapse was attributed to a combination of a faulty stacking plan and water leaking into the ANFO stack (Ammonium Nitrate is extremely soluble in water). It was decided to remove all the material that had already been stacked, and to begin again. A new stacking plan was developed and eventually used for the entire 120-ton (108.9-metric-ton) stack. This revised plan is similar to that used in the TNT stack. As many of the ANFO bags as could be salvaged were re-used in the new stack. Stacking re-commenced on Monday, 14 September, and was completed on Wednesday, 16 September. Detailed dimensions of the completed charge are presented in Tables 2-3 and 2-4.

The stacking crew consisted of 11 workers: 7 men from the University of New Mexico Civil Engineering Research Facility (CERF), 3 stacking supervisors from NSWC/WOL and one-half time from both the DICE THROW Technical Director and a White Sands Missile Range (WSMR) conveyor operator. A total of 297 man-hours were required in restacking the entire 120-ton (108.9-metric-ton) charge.

The internal temperature of the stack, as well as the air temperature, was monitored with a dual-channel thermistor recorder. The stack sensor was located in the fourth layer above the base, about 3 ft (0.91 m) from the edge of the charge.

Table 2-2. Booster System Details

Location	Height Above Base (Feet)	Octol Weight (Pounds)	Pentolite Weight (Pounds)	Detonator Lot #	Detonator Serial #
1	.21 (0.06 m)	28.54 (12.95 kg)	1.99 (.90 kg)	371	219 263
2	2.32 (0.71 m)	28.73 (13.03 kg)	1.99 (.90 kg)	371	265 269
3	4.44 (1.35 m)	28.78 (13.05 kg)	1.98 (.90 kg)	371	288 323
4	6.55 (2.0 m)	29.00 (13.15 kg)	1.98 (.90 kg)	371	352 355
5	8.67 (2.64 m)	29.18 (13.18 kg)	1.98 (.90 kg)	371	370 383
6	10.78 (3.29 m)	29.16 (13.23 kg)	1.98 (.90 kg)	371	385 395
7	12.90 (3.93 m)	29.22 (13.25 kg)	1.98 (.90 kg)	371	432 455

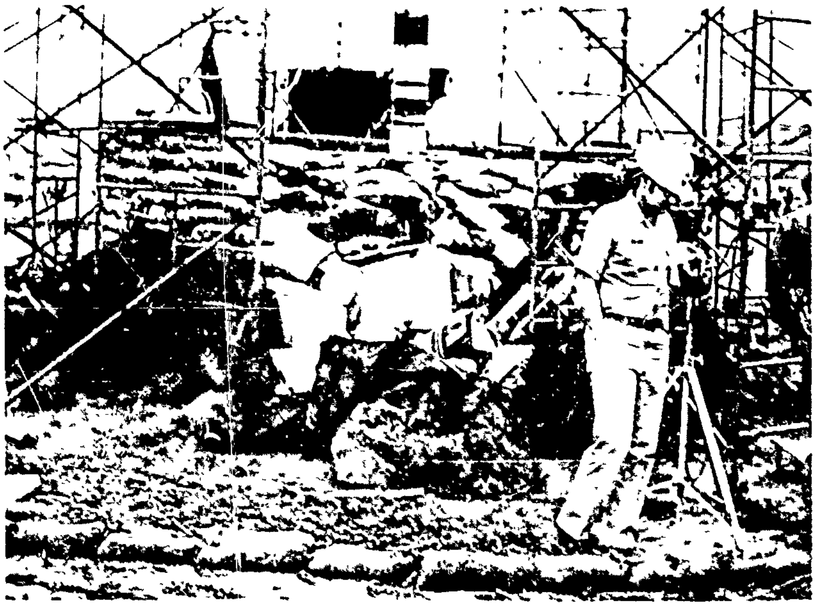


Figure 2-15. Collapsed ANFO Stack, Pre-DICE THROW II, Event II

Table 2-3. Details of Cylindrical Section

Layer Number	Layer Radius Feet	Layer Radius Meters	Height* Above Ground Feet	Height* Above Ground Meters	Design Height* Above Ground Feet	Design Height* Above Ground Meters
1	8.74	2.66	0.21	.06	0.20	.06
2			0.62	.19	0.61	.19
3			1.04	.32	1.02	.31
4			1.45	.44	1.43	.44
5			1.86	.57	1.84	.56
6			2.28	.69	2.25	.69
7			2.69	.82	2.66	.81
8			3.10	.94	3.07	.94
9			3.52	1.07	3.48	1.06
10			3.93	1.20	3.89	1.19
11			4.35	1.33	4.30	1.31
12			4.76	1.45	4.71	1.44
13			5.18	1.58	5.12	1.56
14			5.59	1.70	5.53	1.69
15			6.00	1.83	5.94	1.81
16			6.42	1.96	6.35	1.94
17			6.83	2.08	6.76	2.06
18			7.24	2.21	7.17	2.19
19			7.66	2.33	7.58	2.31
20			8.07	2.46	7.99	2.44
21			8.49	2.59	8.40	2.56
22			8.90	2.71	8.81	2.69
23			9.30	2.83	9.21	2.81
24			9.71	2.96	9.63	2.94
25			10.12	3.08	10.04	3.06
26			10.52	3.21	10.45	3.19
27			10.93	3.33	10.86	3.31
28			11.34	3.46	11.27	3.44
29			11.75	3.58	11.68	3.56
30			12.15	3.70	12.09	3.96
31			12.56	3.83	12.50	3.81
32			12.97	3.95	12.90	3.93

*To Center of Layer

Table 2-4. Details of Hemispherical Cap

Layer Number	Layer Radius Feet	Meters	Height* Above Cylinder Feet	Meters	Design Height* Above Cylinder Feet	Meters
33	8.74	2.66	0.19	.06	0.22	.07
34	8.60	2.62	0.57	.17	0.66	.20
35	8.43	2.57	0.95	.29	1.10	.34
36	8.19	2.50	1.33	.41	1.54	.47
37	8.02	2.44	1.71	.52	1.98	.60
38	7.85	2.39	2.09	.64	2.42	.74
39	7.65	2.33	2.47	.75	2.86	.87
40	7.44	2.27	2.85	.87	3.30	1 01
41	7.10	2.16	3.23	.98	3.74	1.14
42	6.77	2.06	3.61	1.10	4.18	1.27
43	6.44	1.96	3.99	1.22	4.62	1.41
44	6.02	1.83	4.37	1.33	5.06	1.54
45	5.60	1.71	4.75	1.45	5.50	1.68
46	5.10	1.55	5.13	1.56	5.94	1.81
47	4.56	1.39	5.51	1.68	6.38	1.94
48	3.85	1.17	5.89	1.80	6.82	2.08
49	3.32	1.01	6.27	1.91	7.26	2.21
50	2.91	.89	6.65	2.03	7.70	2.35
51	2.10	.64	7.03	2.14	8.14	2.48
52	1.74	.53	7.41	2.26	8.58	2.62

*To Center of Layer

Samples were taken from each layer of the charge and analyzed for both fuel oil content and particle-size distribution (refer to the photo's in Figure 2-16). In addition, several samples were collected at the mixing plant in Estancia, just prior to shipment. Based on 203 samples, the average ANFO bag in the charge weighed 50.82 lbs (23.05 kg), with the empty bag weighing 0.5 lb (0.23 kg). The total amount of material loaded into the charge was 123.62 tons (112.15 metric tons) (this figure includes the weight of the paper bags, booster, PVC pipe and flanges, cabling and cardboard tubing). The weight of the ANFO and booster was 122.45 tons (111.09 metric tons).

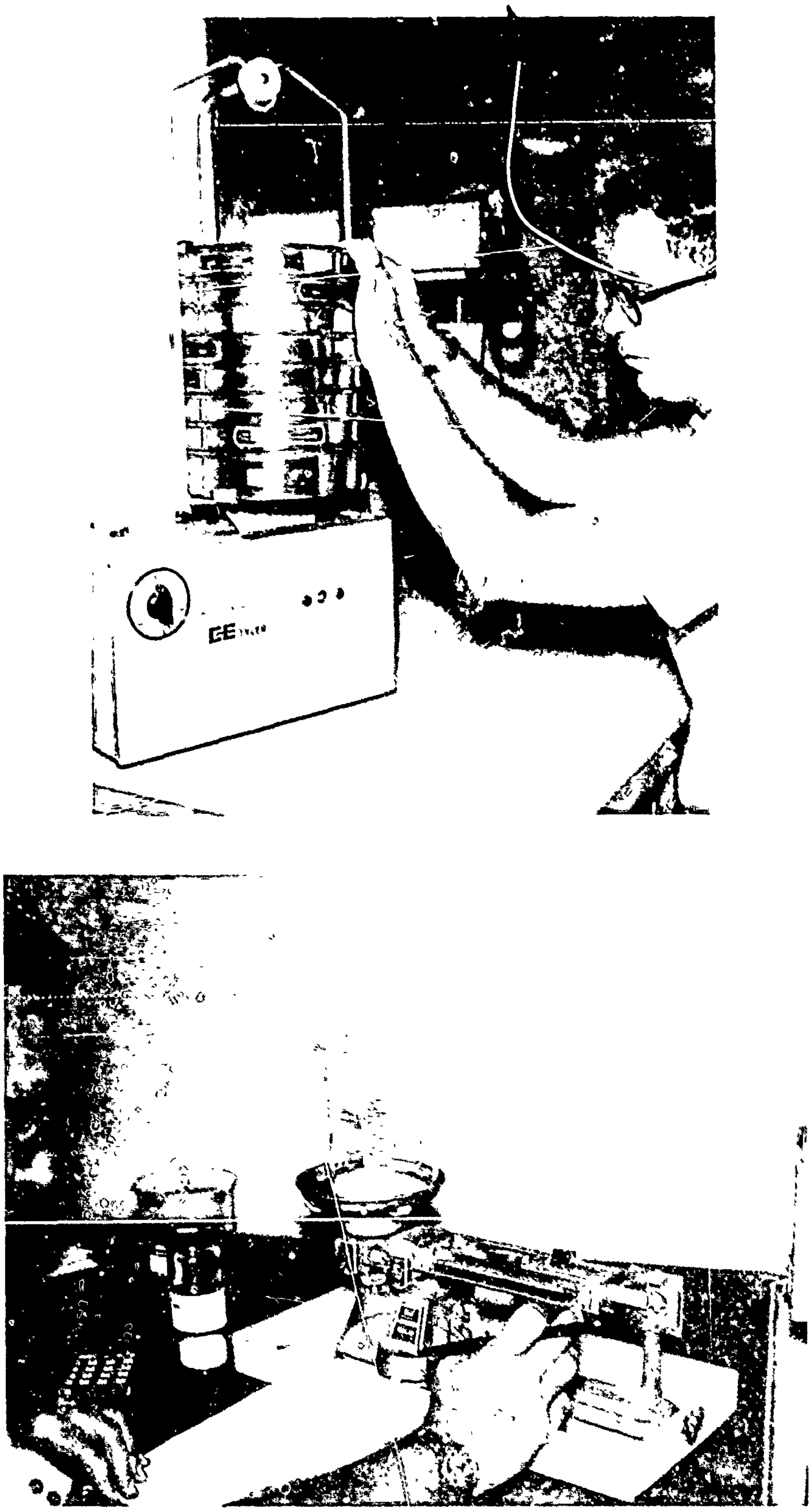


Figure 2-16. Particle-Size Distribution and Fuel Oil Content Measurements made by NSWC, Pre-DICE THROW II

TIMING AND FIRING

1. Timing and Monitoring

The U. S. Army Engineer Waterways Experiment Station (WES) provided the T&I and monitor requirements of the experimenters on Pre-DICE THROW II-1 and -2. The timing and monitor requirements are shown in Tables 2-5 [100-ton (90.7-metric-ton) TNT event] and 2-6 [120-ton (108.9-metric-ton) ANFO event]. The T&I requirements for the CIST were provided by the CIST van.

2. High-Voltage Firing System Description

(a) Firing System. The firing system for the CIST is an integral part of the CIST instrumentation van. An overall block diagram for this system is shown in Figure 2-17. Only one field X-unit is shown for simplicity; however, two units are actually used, as indicated in Figure 2-5. Details concerning safety are found in the Safety Plans for the CIST Program, September 1972. Operational details are located in AFWL TR-74-136

The firing system used for the Pre-DICE THROW II-1 and -2 projects was one which had been field proven on a number of prior events. The firing system consists of components mounted in a console located in the T&I trailer plus one or two firing supplies located near GZ. A generalized block diagram of the system is shown in Figure 2-18. When in operation, the central unit is driven from an IRIG clock generator through a countdown unit. Discrete time signals from the countdown unit are used to control the safety interlock relay and arming circuits for detonating the charge. These circuits furnish the supply voltage, trigger pulse and safety relay voltage to the forward X-units. These circuits are controlled by a keylock switch and are effective only after the key is inserted into the control unit.

(b) System Operation. A typical sequence of events for using this system is as follows:

(1) When detonators are to be fired for check-out or actual test, the keylock switch is turned to the off position and the key withdrawn from the lock. In addition to this safety precaution,

Table 2-5. 100-Ton (90.7-Metric-Ton) TNT Timing-and-Firing and Monitoring Requirements

	-5 min	-4 min	-3 min	-2 min	-1 min	-30 sec	-15 sec	-6 sec	-5 sec	-4 sec	-3 sec	-1 sec	0 sec	IRIG A	IRIG B	FIDU	Tape Run Monitor	Remarks
Sandia	(2) X	(2) X												X	X	X		
SRI & SSS				(2) X		(2) X		(2) X		(2) X						X		
BRL			(6) X	(6) X	(2) X	(2) X								X		X	(2)* X	*One monitor-four recorders in series. One monitor-two recorders in series-TRW's Trench experiment airblast measurements and Separated for shot hold conditions
WES				(2) X		(2) X						(2) X			X	X		
DRI									(1)* X			(1) X				X		*Latching relay
AFWL														X		X		
NRD							(1) X								X			
Strong Motion Seismic									(1) X		X		X					Closure supplied with 50 volts DC - contact closed @ -5 sec, open at -3 sec, closed at 0 sec
DRES									(2) X			(2) X				X		

NOTE: 1. All closures held in until +8 sec unless otherwise noted.

2. The numbers in parentheses in each block indicate the numbers of contacts required by experimenters.

Table 2-6. 120-Ton (108.9-Metric-Ton) ANFO Timing-and-Firing and Monitoring Requirements

	-3 min	-2 min	-1 min	-30 sec	-15 sec	-10 sec	-6 sec	-5 sec	-4 sec	-3 sec	-1 sec	-3.5 msec	0 sec	IRIG A	IRIG B	FIDU	Tape Run Monitor	Remarks
BRL	(6) X	(6) X	(2) X	(2) X										X		X	X*	*All six tape machines (RUN) on one monitor
Strong Motion Seismic						(1) X				X			X					One contact with 50 volts DC - closed at -10 sec, open at -3 sec, closed at 0 sec.
WES		(2) X		(2) X							(2) X				X	X		
DRI								(1)* X			(1) X					X		*Latching relay
NWEL	(2) X	(2) X			(2) X			(2) X							X	X		
NRD					(1) X										X	X		
AFWL												(1)* X		X		X		*T&F provided 150 ms closure-this closure then delayed in the AFWL van
SRI & SSS		(2) X		(2) X			(2) X		(2) X							X		
LLL																X		

NOTE: 1. All closures held in until +8 sec unless otherwise noted.

2. The numbers in parentheses in each block indicate the numbers of contacts required by experimenters.

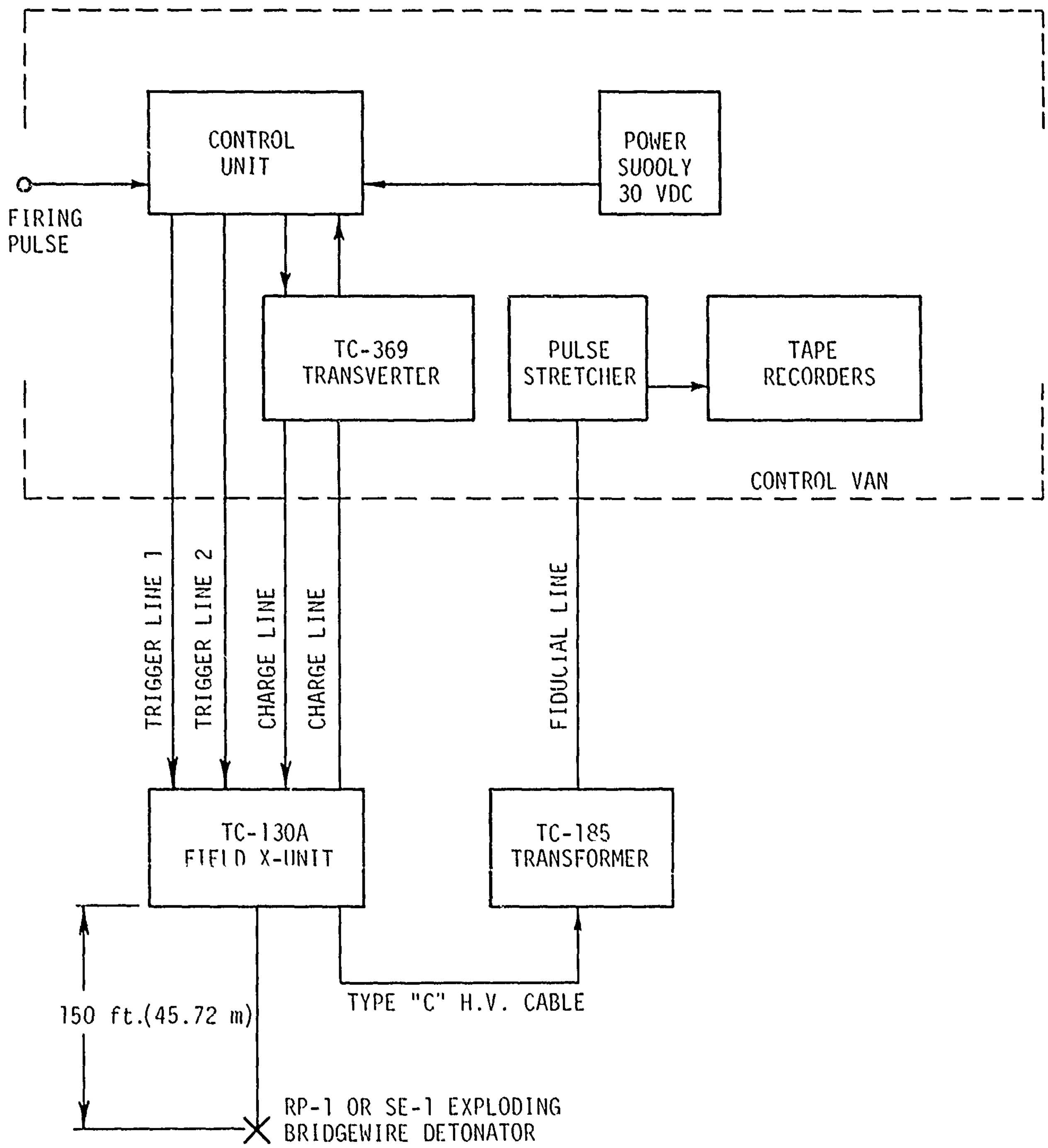


Figure 2-17. AFWL CIST Firing System Block Diagram, Pre-DICE THROW II

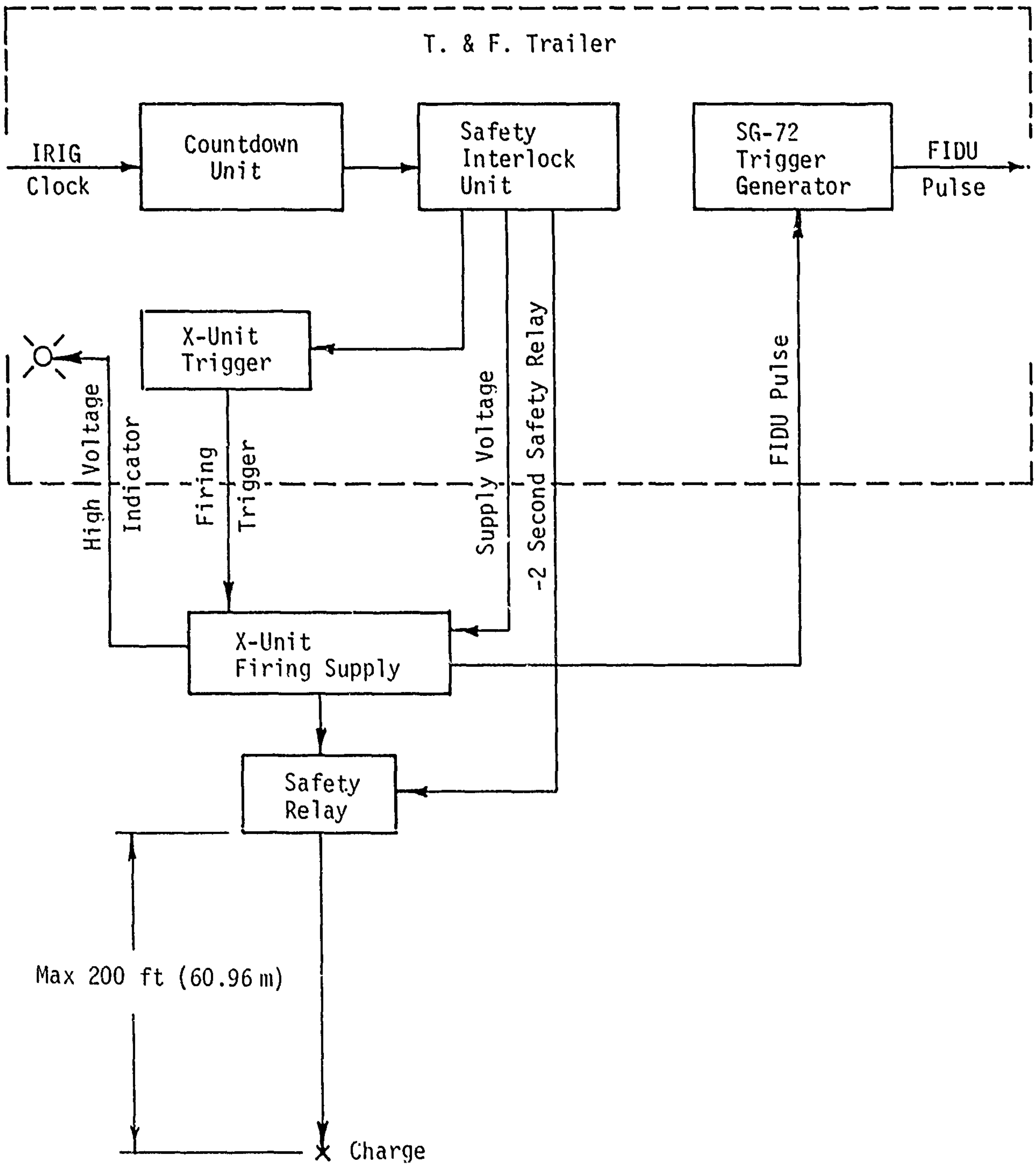


Figure 2-18. Firing System for Pre-DICE THROW II

all cables from the console unit to the X-unit firing supply are disconnected from the console and the cable connectors locked in a box.

(2) The arming party will have the keys to the firing system and to the lockbox in which all cables going to the field components have been secured. After the arming party has placed the detonators in the boosters and completed hookup of the detonator leads to the firing line (at the safety relay box), they will return the keys to the control unit operator. At the appropriate time in the countdown, the key to the lock switches will be inserted and the unit turned on. The firing supply cables are removed from the lockbox and reconnected. The remote indicating devices are observed and the T&F operator will be apprised of a "go" or "no-go" condition. After this, the firing sequence is under the control of the T&F console.

(3) When the countdown sequence reaches zero time, a 28-volt trigger pulse is sent to the X-unit which discharges the high voltage, firing the detonators.

The system described previously was used with two RP-1 detonators fired in parallel from one X-unit for the TNT event. The ANFO event firing required two X-units, each having seven RP-1 detonators in series, as shown in Figure 2-13.

CABLE REQUIREMENTS

PROJECT TITLE: Cable Coordination - Support to DNA Field Command

PROJECT OFFICER: Mr. R. Ward, EG&G, Inc. (702) 986-9252

SUPPORT DESCRIPTION: The cable required for Pre-DICE THROW II was obtained from the DNA cable storage area at NTS. The experimenter cable requirements were obtained by Field Command via the Technical Support Plans. The majority of the cable used on the 100-ton (90.7-metric-ton) TNT event was also used on the 120-ton (108.9-metric-ton) ANFO event (refer to Figure 2-1 for layout of both events with respect to the instrumentation park). Table 2-7 indicates the cable distribution to the experiment agencies for both events.

Table 2-7. Experiment Cable Requirement on Pre-DICE THROW II, Events 1 and 2

	20 TSP #22	RG 213 u	4/C #22	WD-7 (Field Wire)	50 pair #19	6 pair #19	RG 58 c/u	RG 331	Remarks
EVENT 5									
SLA	25 (7.62)	11 (3.35)							
TRW/SAMSO	20.6 (6.28)	16.5 (5.03)	30 (9.14)	12.5 (3.81)					
BRL	60 (18.29)		115 (35.05)						
SSS	5 (1.52)		20 (6.10)						
SPI		11.73 (38.5)							
WES	5 (1.52)	13.5 (4.11)	120 (36.58)	10 (3.05)	60 (18.29)	10 (3.05)	2.5 (.76)		
ORI		7.5 (2.29)		25 (7.62)					
EVENT 6									
BRL			72 (21.95)						12,000 ft (3,657.6 m) was replaced due to wet cable
SSS			30 (9.14)						10,000 ft (3,048 m) was replaced due to wet cable
SPI		2.5 (.76)							
[illegible]		27.5 (8.38)						10 (3.05)	
WES			175 (53.34)						
TOTAL CABLE:	115.6 (35.23)	[illegible] (35.97)	562 (171.[illegible])	17.5 (5.33)	60 (18.29)	10 (3.05)	2.5 (.76)	10 (3.05)	

NOTE. Cable quantities in 1000's of feet (meters)

ENVIRONMENTAL MONITORING

Samples of soil and water were taken from the Pre-DICE THROW II site locations for analysis. A letter report written by G.E. TEMPO describes the results of these analysis. Refer to the photographs in Figure 2-19.

QUEEN 15 PRE-DICE THROW II SITE AND EXPERIMENT LAYOUT AND DESCRIPTION

Site Description

The overall testing area for the CIST, TNT and ANFO events is shown in Figure 2-1. An area of approximately 40,000 ft^2 (3716.12 m^2) was cleared around GZ 5 and GZ 6 to accommodate the experiments and technical photography requirements. Each of the events had unique site preparations, and they will be addressed later.

CIST Experiment Description (DNA Project No. 160-72)

AFWL PROJECT OFFICER: Mr. C. Noble

TEST OBJECTIVE: This test was designed to measure the dynamic response of the site area geology to a cylindrically symmetrical high-explosive shock input, the data obtained providing a data base from which the in-situ dynamic material properties may be determined. These properties are required to adequately define the constitutive relationships needed for free-field computer calculations.

The CIST site layout is shown in Figure 2-20. Figure 2-21 shows the ground structure and gages. Four types of measurements were made: cavity pressure, acceleration (horizontal and vertical), stress and strain. A total of 44 channels of data were recorded. Cavity pressure was measured at six locations inside the main CIST pipe. Acceleration measurements were made out to 75 feet (22.86 m) from GZ (total of 32 gages). The six stress and strain measurements were made 5 and 8 feet (1.52 and 2.44 m) from GZ. Refer to Figures 2-22, 2-23 and 2-24 for details on gage placement and hole locations. Table 2-8 indicates the hole diameters and depths. A block diagram of the CIST instrumentation is shown in Figure 2-25.

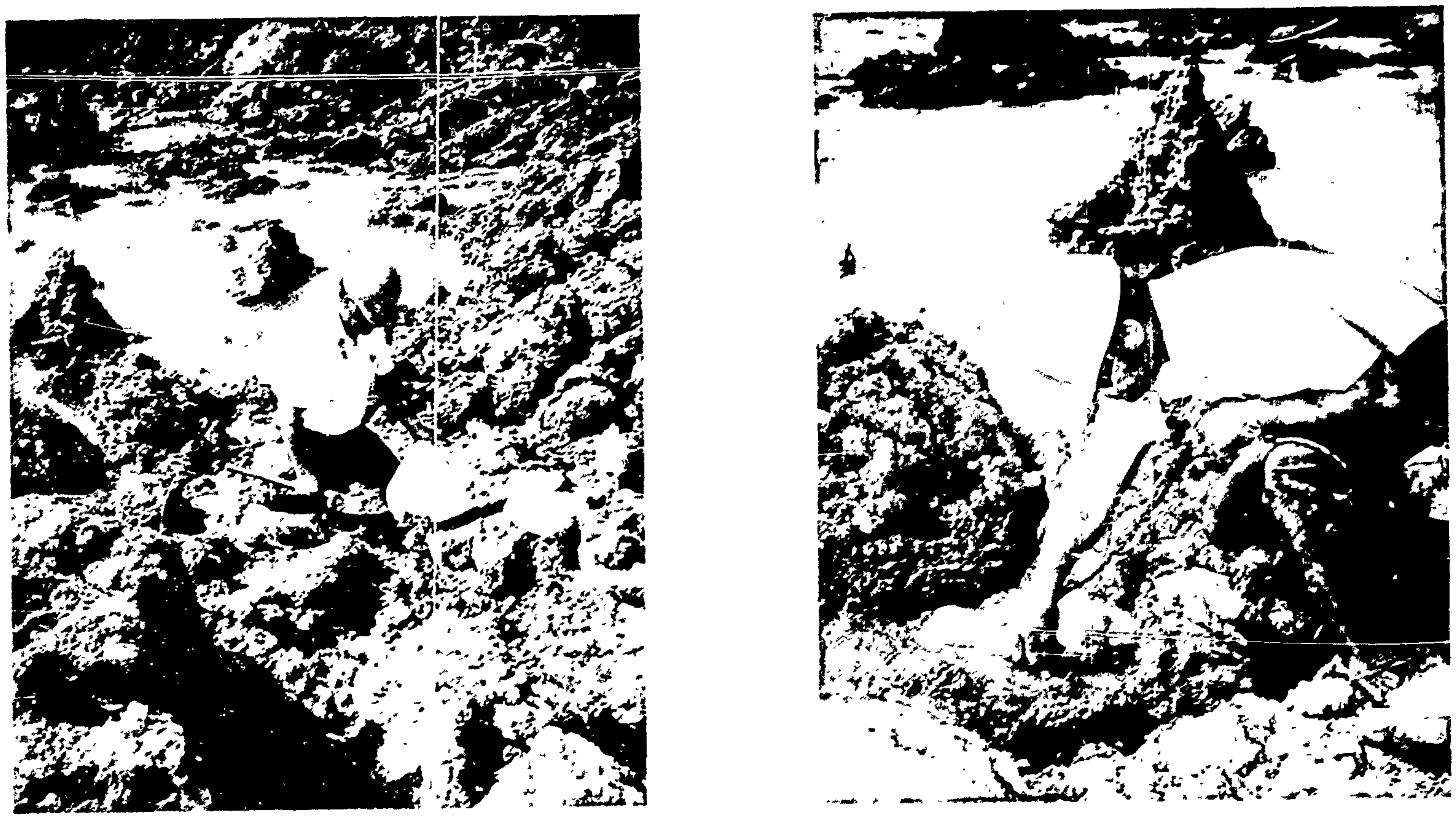


Figure 2-19. Soil and Water Samples Taken at the Pre-DICE THROW II Site Location by G. E. TEMPO

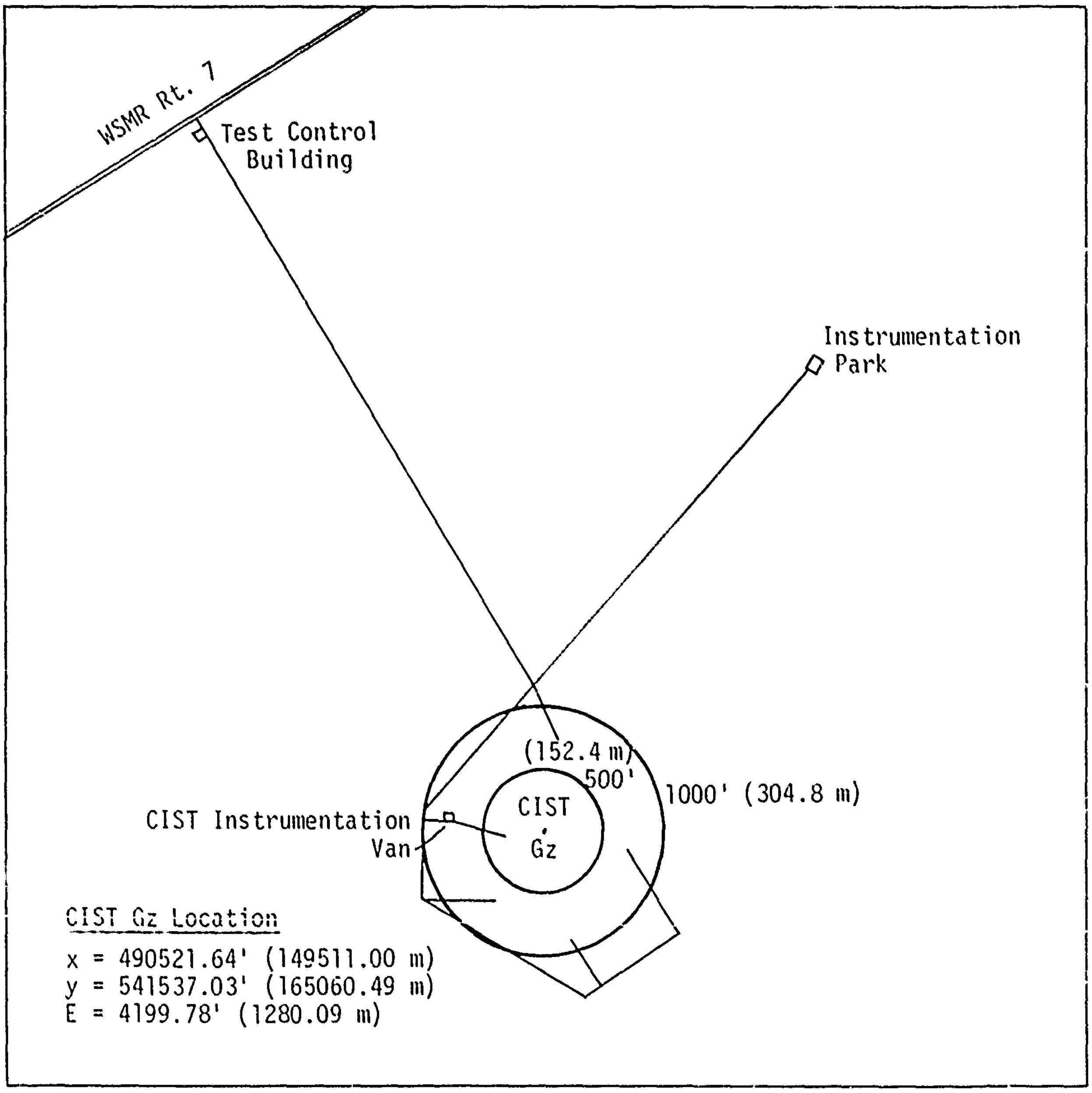


Figure 2-20. AFWL CIST Site Layout,
Pre-DICE THROW II

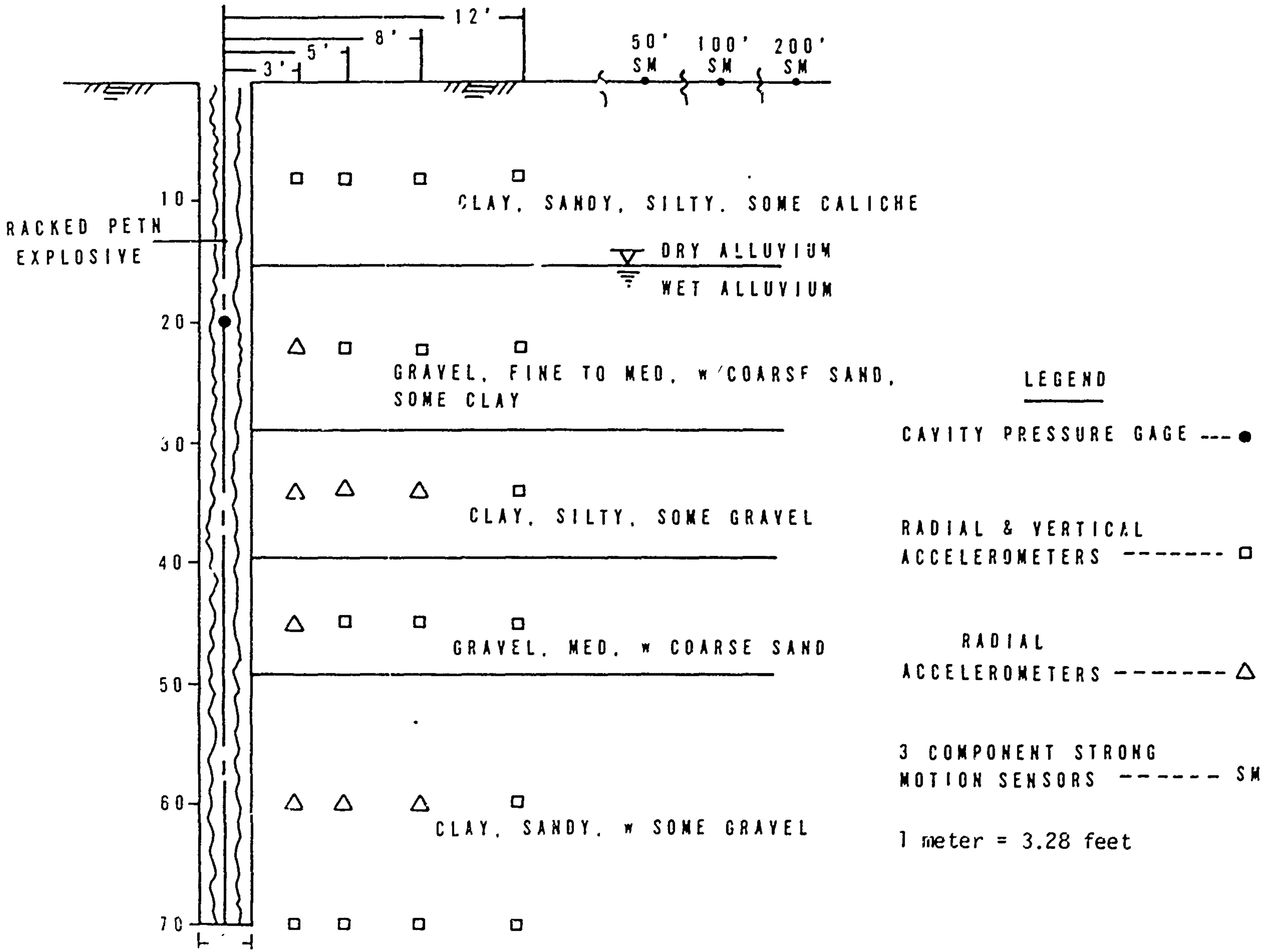


Figure 2-21. Pre-DICE THROW CIST Geology and Measurements

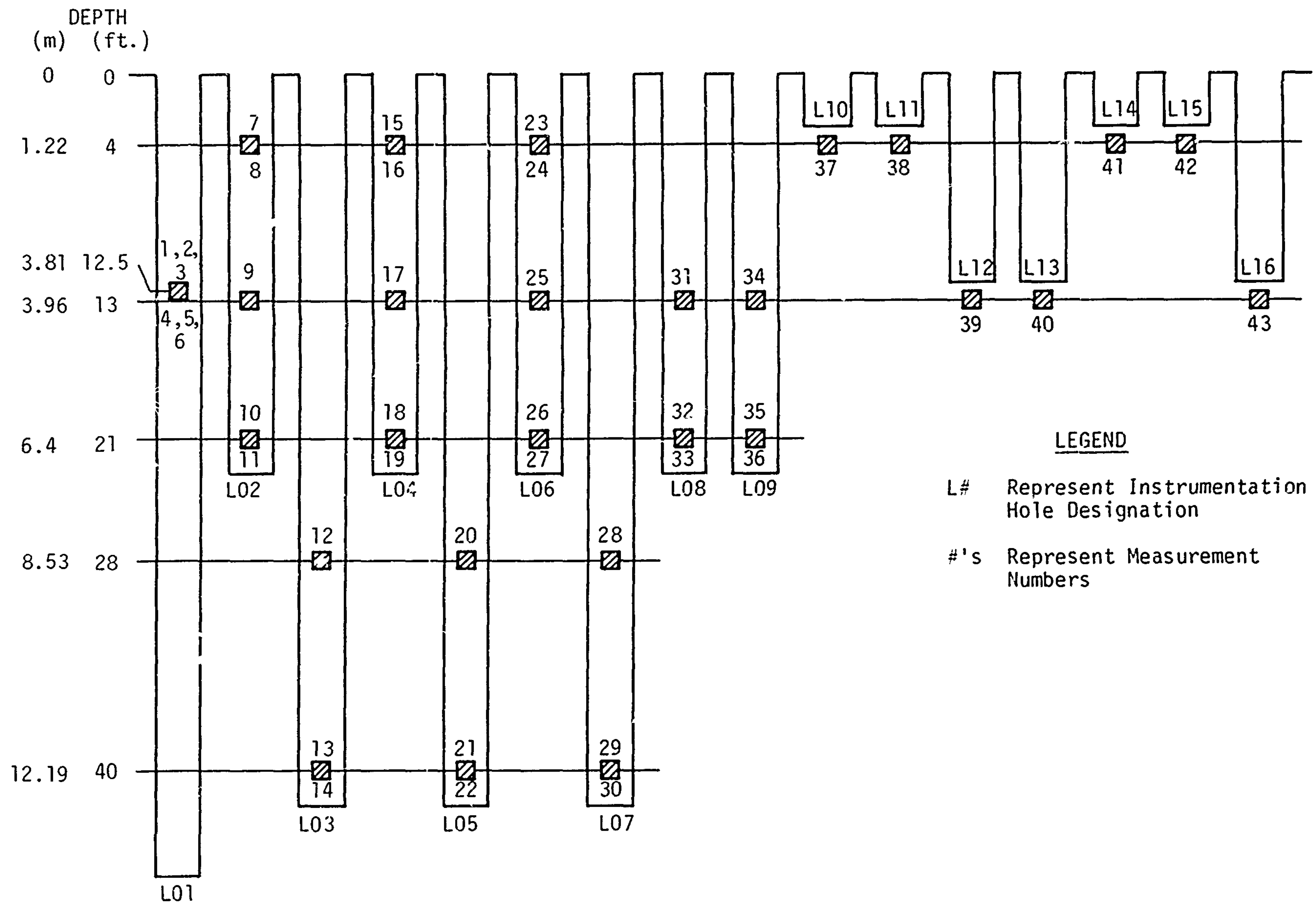
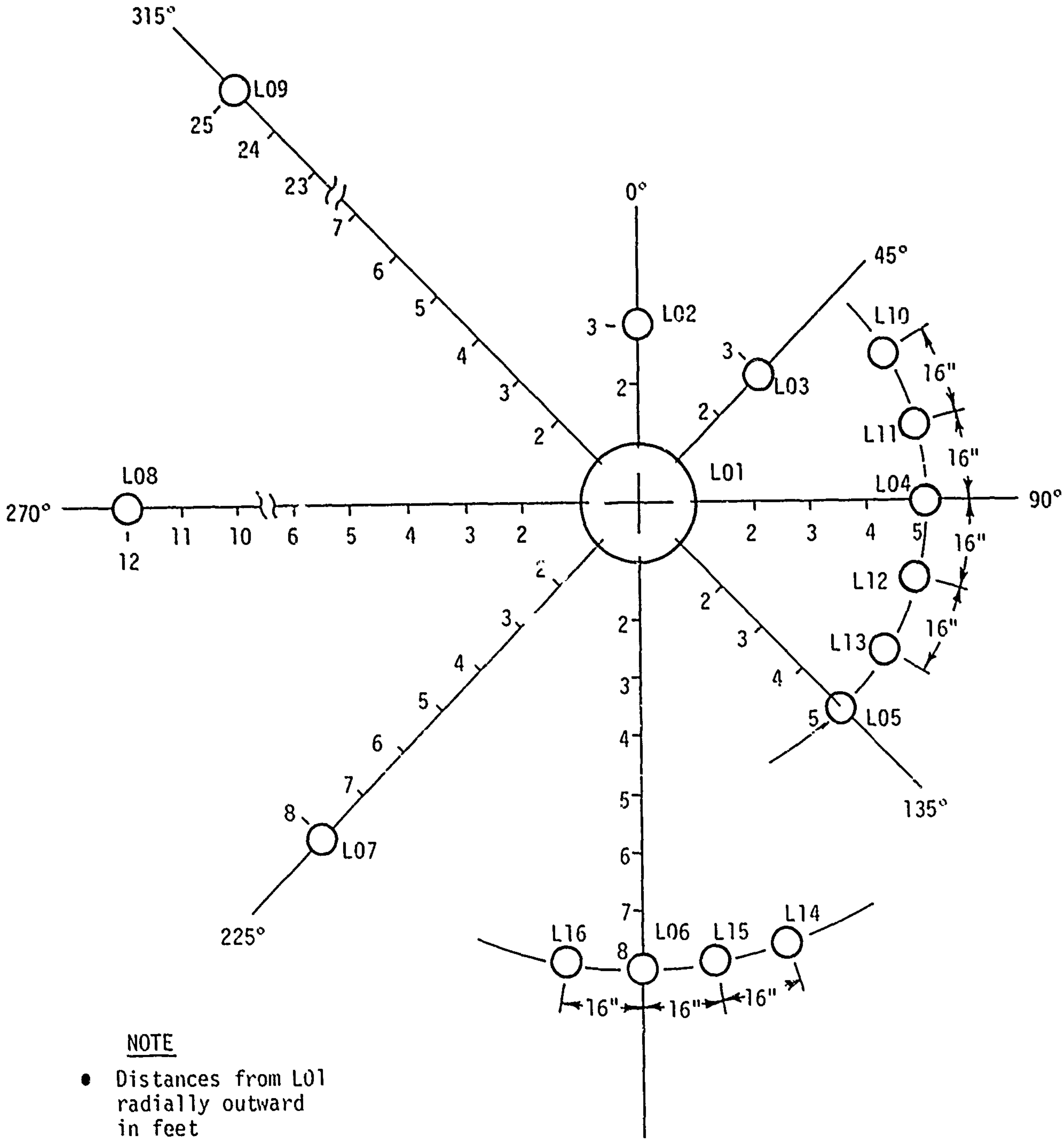


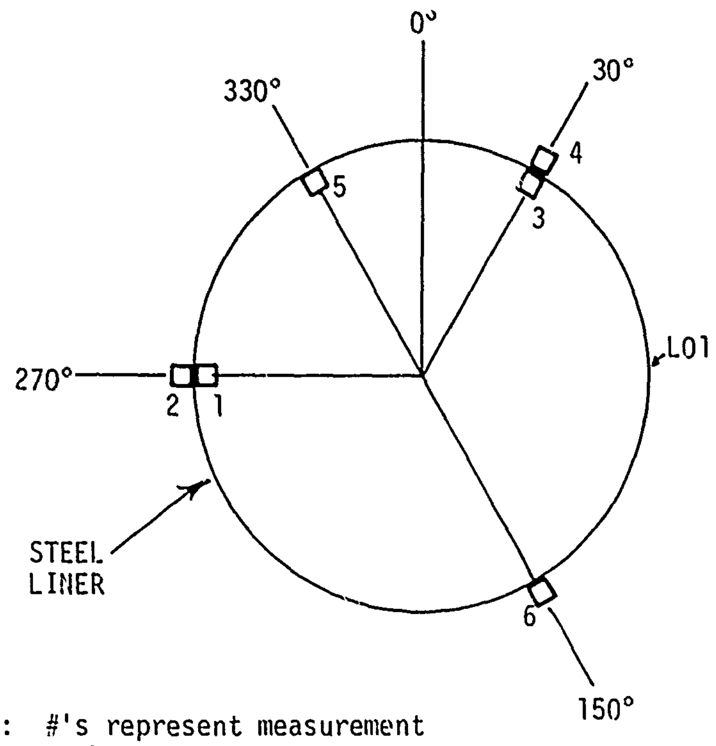
Figure 2-22. AFWL Transducer Placement for CIST, Pre-DICE THROW II



NOTE

- Distances from L01 radially outward in feet
- 1 in. = 2.54 cm

Figure 2-23. AFWL CIST Hole Configuration, Pre-DICE THROW II



NOTE: #'s represent measurement numbers

Figure 2-24. AFWL CIST Cavity Pressure Transducer Placement, Pre-DICE THROW II

Table 2-8. Transducer Hole Configurations - CIST

Hole Number	Diameter		Depth	
	(inches)	(cm)	(feet)	(m)
L01	28	71.12	41.3	12.59
L02	7	17.78	23	7.01
L03	7	17.78	42	12.80
L04	7	17.78	23	7.01
L05	7	17.78	42	12.80
L06	7	17.78	23	7.01
L07	7	17.78	42	12.80
L08	7	17.78	23	7.01
L09	7	17.78	23	7.01
L10	7	17.78	3	.91
L11	7	17.78	3	.91
L12	7	17.78	12	3.66
L13	7	17.78	12	3.66
L14	7	17.78	3	.91
L15	7	17.78	3	.91
L16	7	17.78	12	3.66

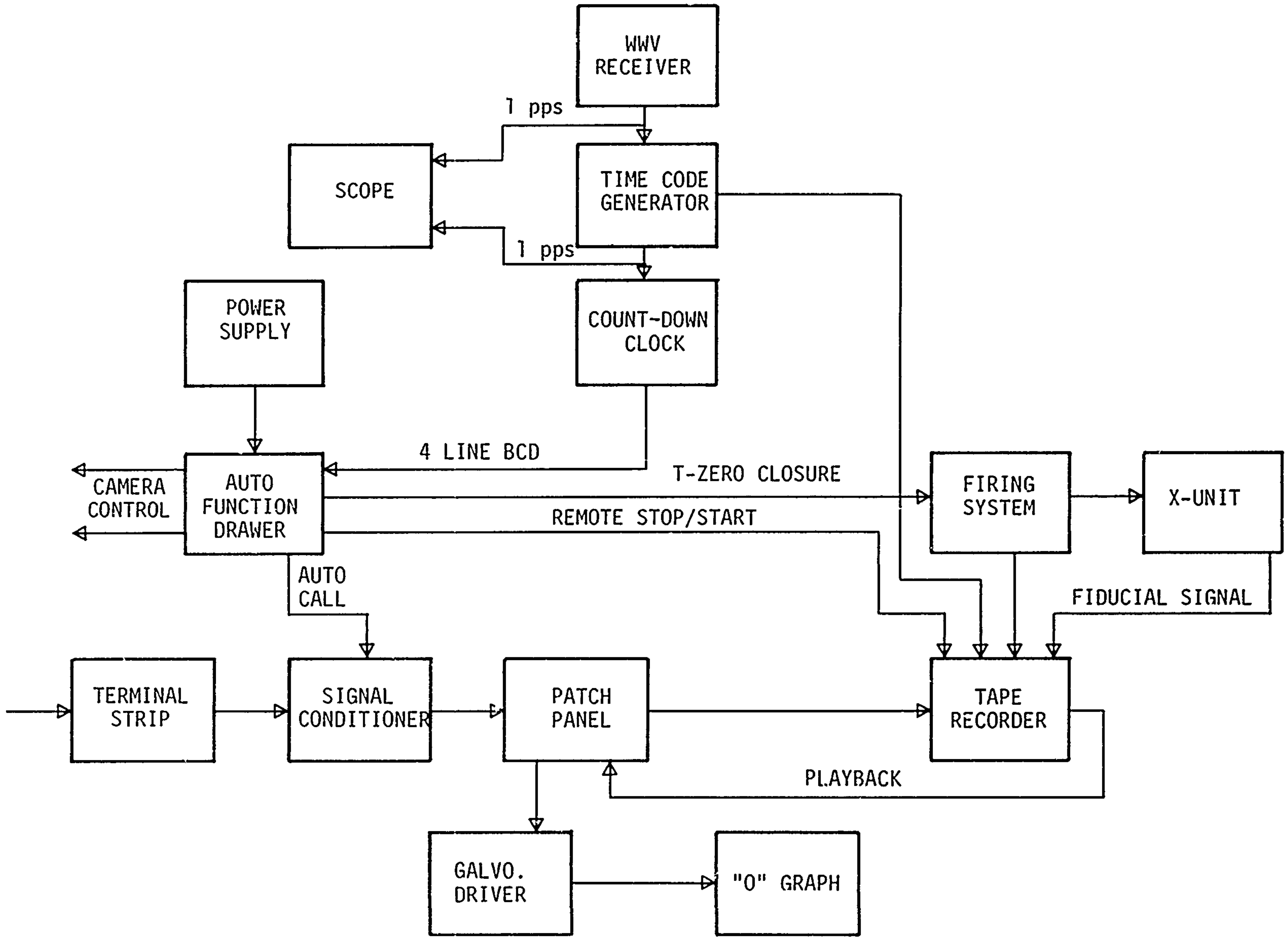


Figure 2-25. AFWL CIST Instrumentation Trailer Block Diagram, Pre-DICE THROW II

PRE-DICE THROW II, EVENT 1 (TNT) AND EVENT 2 (ANFO) EXPERIMENT DESCRIPTIONS (Refer to Figures 2-26 and 2-27 for the test-bed layouts for these events)

1. Air Force Weapons Laboratory (AFWL)/Civil Engineering Research Facility (CERF)

   TITLE: Debris (Ejecta) Measurements (DNA Project No. 160-73)

   PROJECT OFFICERS: Dr. R. Henny (AWFL) and Mr. G. Jones (CERF)

   OBJECTIVE: Measure ejecta and correlate crater measurements with prior events.

   EXPERIMENT DESCRIPTION: (Refer to Figures 2-28 and 2-29) Ejecta collectors were placed on four radials extending from 100 to 750 feet (30.48 to 228.60 m). These collectors included cylindrical-shaped bins (placed above the ground surface). In addition, many conventional pan collectors were placed in the test area to identify ejecta density. Post-event measurements of ejecta thickness were made near the crater lip. An examination of missile size and ground coverage was made on Event 2.

2. AFWL/Environmental Research Institute of Michigan (ERIM)/ U. S. Geological Survey (USGS)/Southern Methodist University (SMU)

   TITLE: Seismic Measurements (DNA Project No. 160-76)

   PROJECT OFFICERS: Mr. R. Zbur (AFWL), Mr. R. Turpening (ERIM), Mr. J. Hoffman (USGS), and Dr. G. Herrin (SMU).

   OBJECTIVES: (1) Profile the test-bed area pretest by obtaining seismic refraction and reflection data and study deep-basin structure by analyzing motions generated by the tests; (2) Study charge-coupling phenomena and equivalency of comparable TNT and ANFO charges.

   EXPERIMENT DESCRIPTION: (Refer to Figures 2-30 and 2-31). Thirty-one stations of accelerographs to monitor seismic strong motion were placed in and around the testing area (500 ft (152.4 m) from GZ out to approximately 7 miles

1 kPa = 6.89 psi
1 meter = 3.28 feet

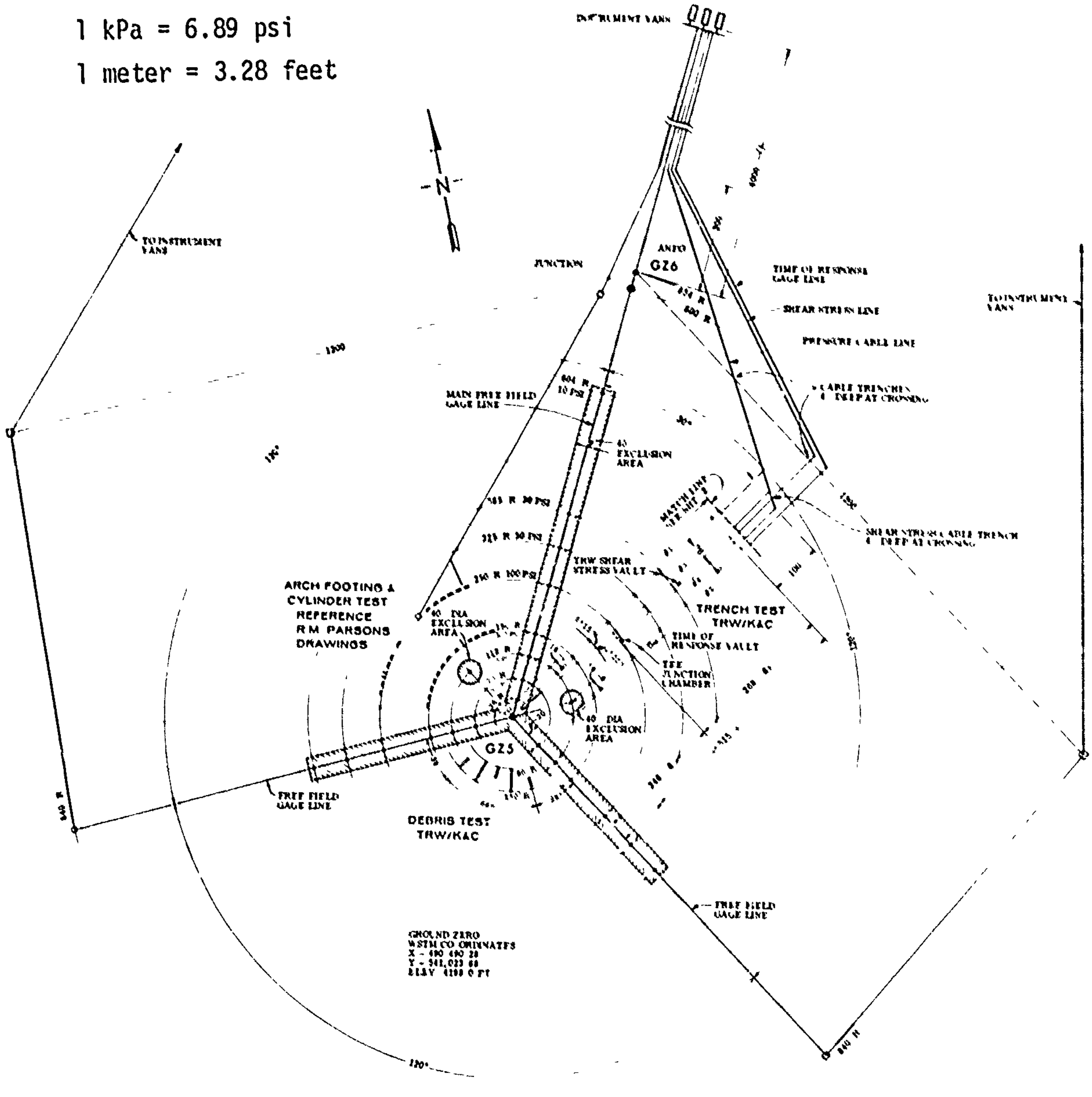


Figure 2-26. Pre-DICE THROW II, Event 1 Test Bed Layout

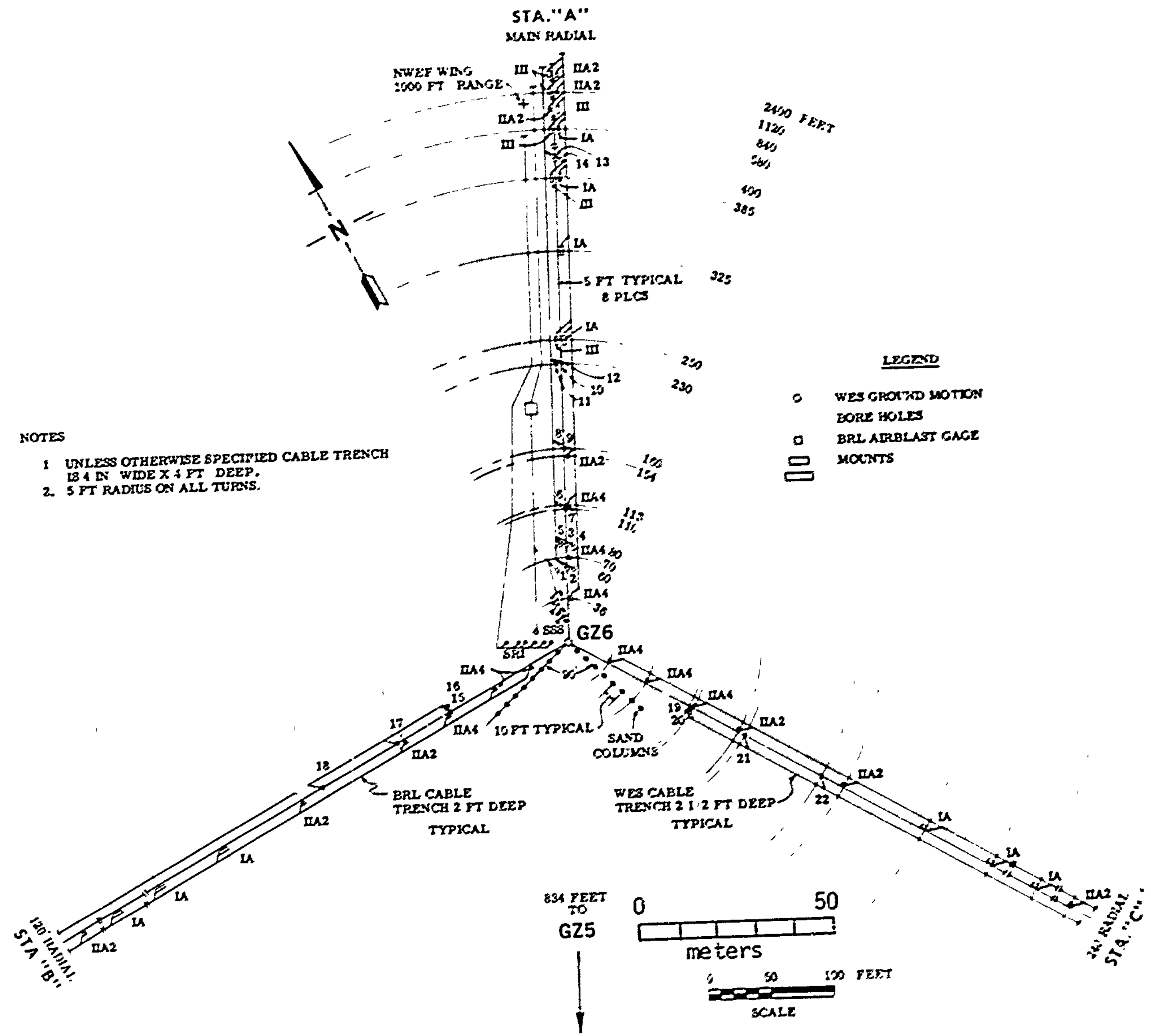


Figure 2-27. Pre-DICE THROW II, Event 2 Test Bed Layout

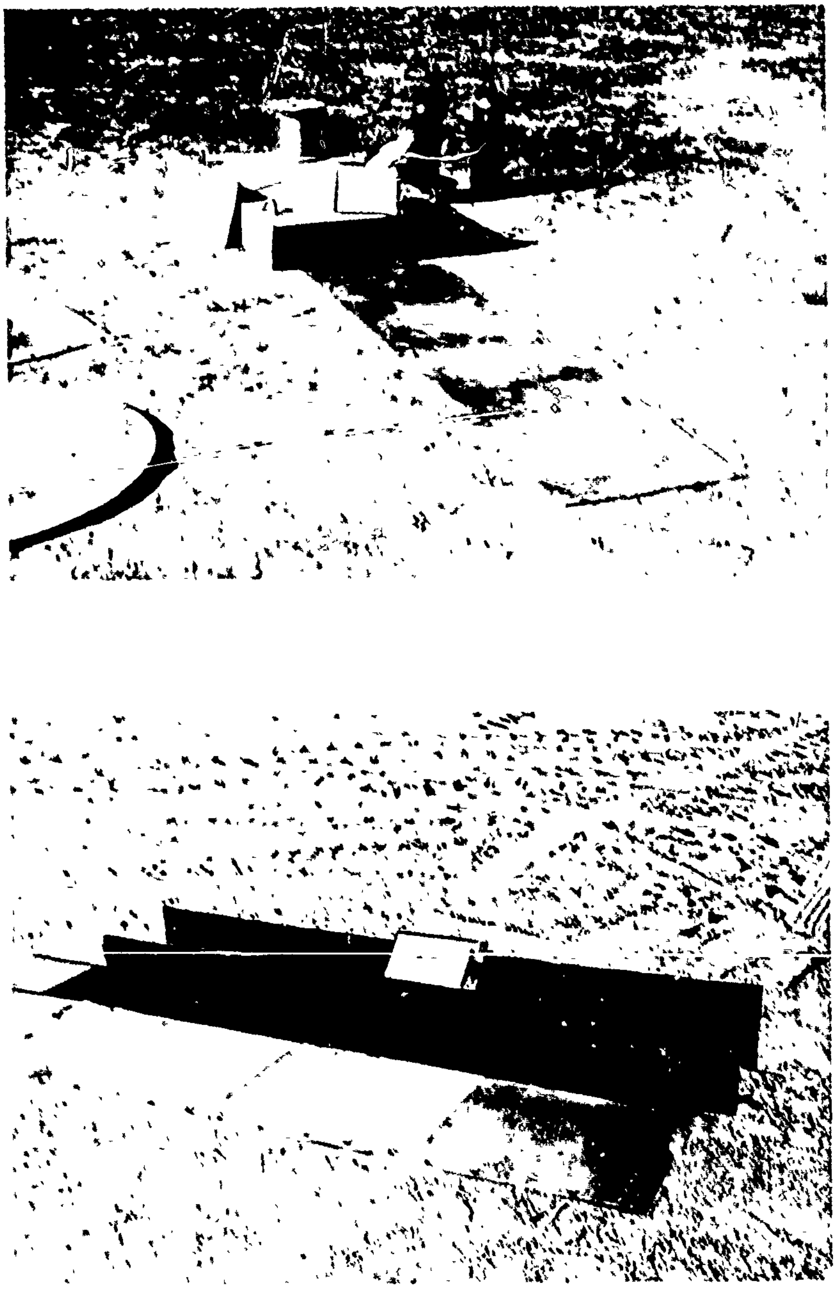


Figure 2-28. Pre-DICE THROW II Ejecta Collectors

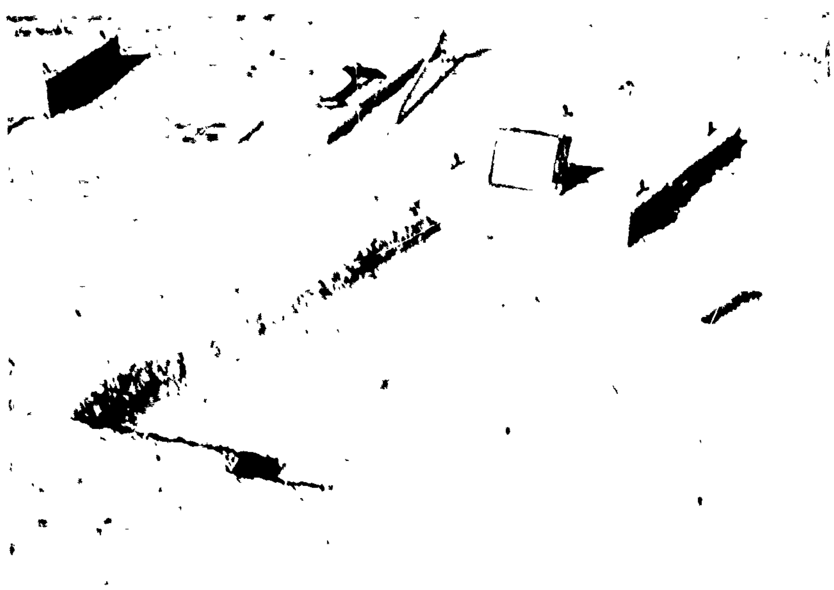


Figure 2-29. Pre-DICE THROW II Ejecta Collector Placement

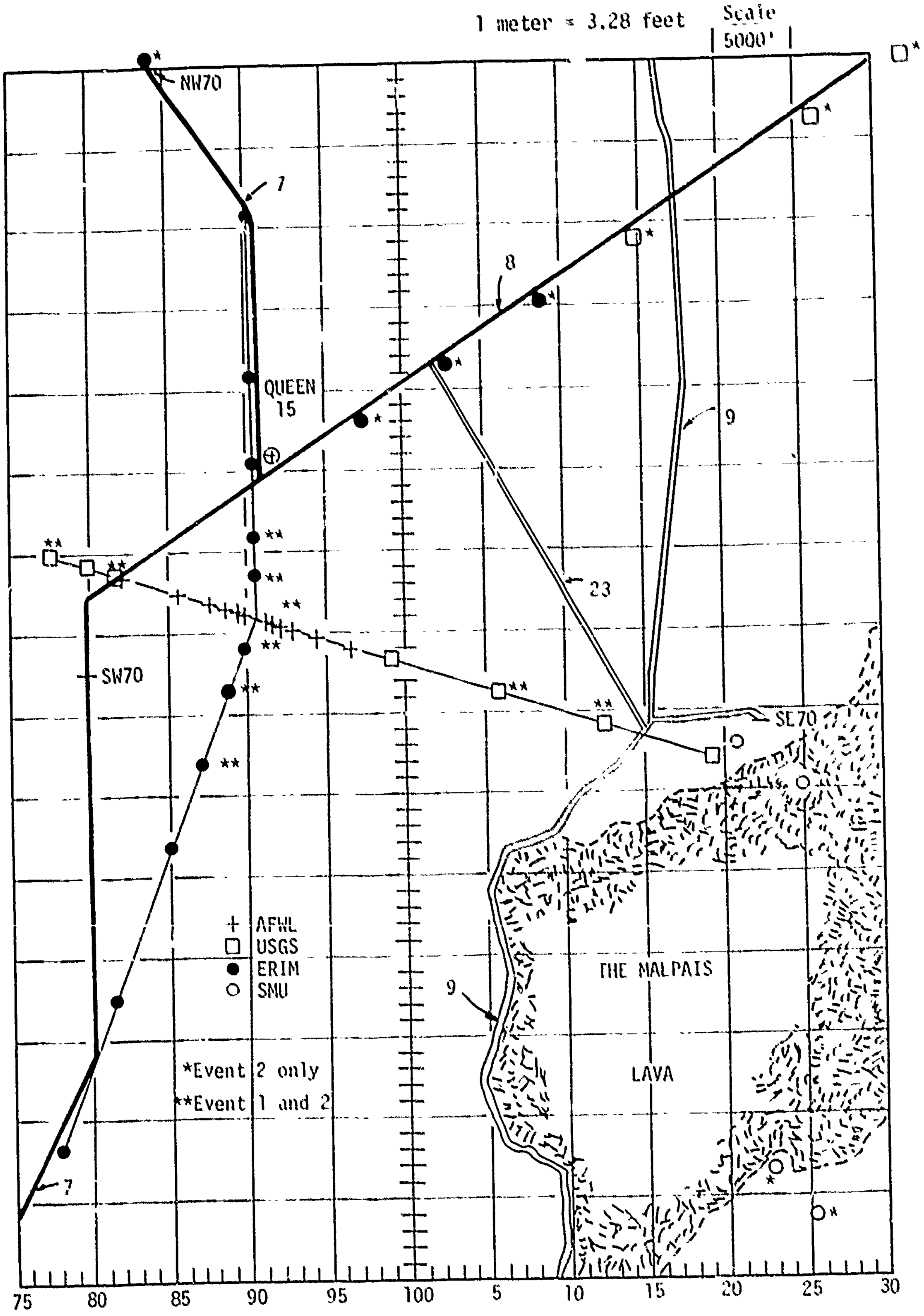


Figure 2-30. Strong-Motion Seismic Experiment Layout, Pre-DICE THROW II, Events 1 and 2

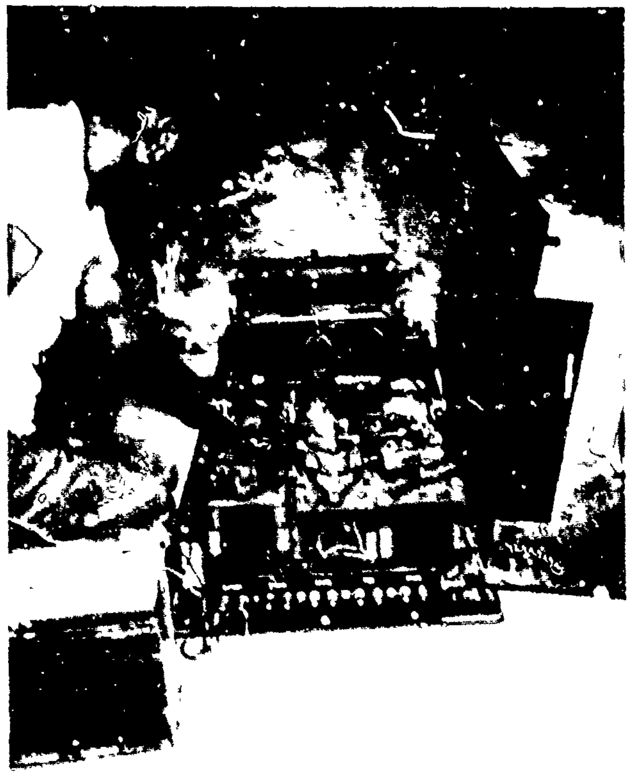


Figure 2-31. Typical Seismic Electronic Package Used On Pre-DICE THROW II

(11.27 km)). Refer to Figure 2-31 for a view of a typical seismograph station.

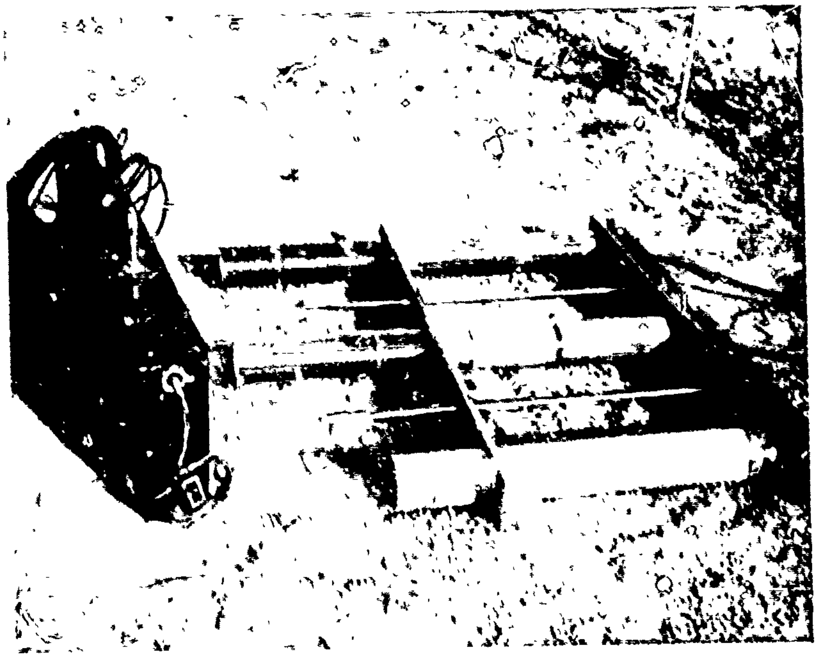
3. AFWL

TITLE: Near-Source Ground Motion Measurements (DNA Project No. 160-74)

PROJECT OFFICER: Mr. J. Renick

OBJECTIVE: Provide near-source measurements of soil motion for comparing the TNT and ANFO sources.

EXPERIMENT DESCRIPTION: (Refer to Figure 2-32.) The transducers fielded were mutual-inductance particle velocimeters (MIPV) developed by the AFWL. Refer to Table 2-9 for gage



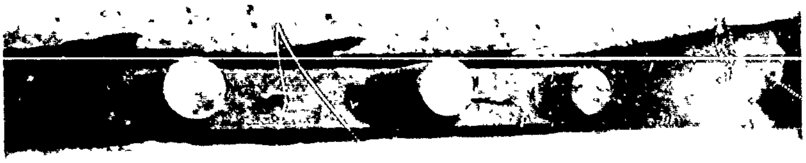


Figure 2-32. Pre-DICE THROW II, Events 1 and 2,
AFWL Ground-Motion Measurement Systems

Table 2-9. Mutual Inductance Particle Velocimeter Locations and Predictions, Pre-DICE THROW II, Events 1 and 2

Event	Gage	Length		Depth		Stress	Particle Velocity
		(in.)	(cm)	(ft)	(cm)	(kb)	(mm/μsec)
PDTII-1	1	25	63.50	1.81	.55	70	1.10
PDTII-1	2	35	88.90	1.17	.36	85	1.25
PDTII-1	3	35	88.90	1.38	.42	80	1.20
PDTII-2	1	45	114.30	1.08	.33	40	.75
PDTII-2	2	36	91.44	2.12	.65	25	.60
PDTII-2	3	24	60.96	3.17	.97	18	.50

design parameters and placement information. Three gages were placed under the charges on each event in narrow radial trenches and backfilled with a low strength grout as shown in Figure 2-33.

The orientation of the gages of the TNT event was approximately 10 degrees from vertical to align the gages with the expected flow field. On the ANFO event, the gages were oriented vertically. The power supplies were located near the gages. Refer to POR 6918 for further details of this experiment.

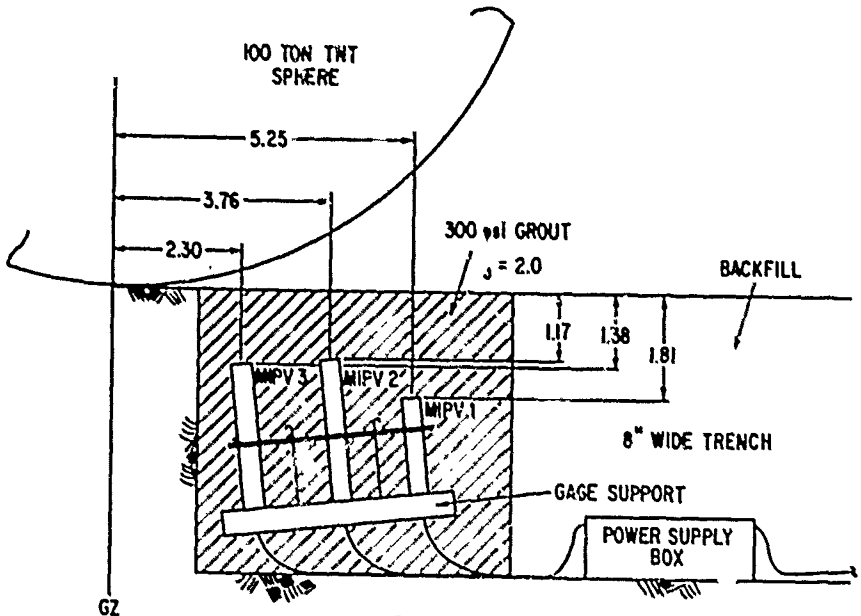
4. Ballistic Research Laboratory (BRL)

TITLE: Free-Field Airblast Measurements (refer to Figures 2-34, 2-35 and POR 6915) (DNA Project No. 160-63).

PROJECT OFFICER: Mr. G. Teel

OBJECTIVE: Document the free-field airblast environment parameters and prepare pre-test predictions.

EXPERIMENT DESCRIPTION: Twenty-two channels of pressure-time instrumentation were installed on the TNT event. The instrument locations were chosen to coincide with the locations of the Waterways Experiment Station (WES) ground

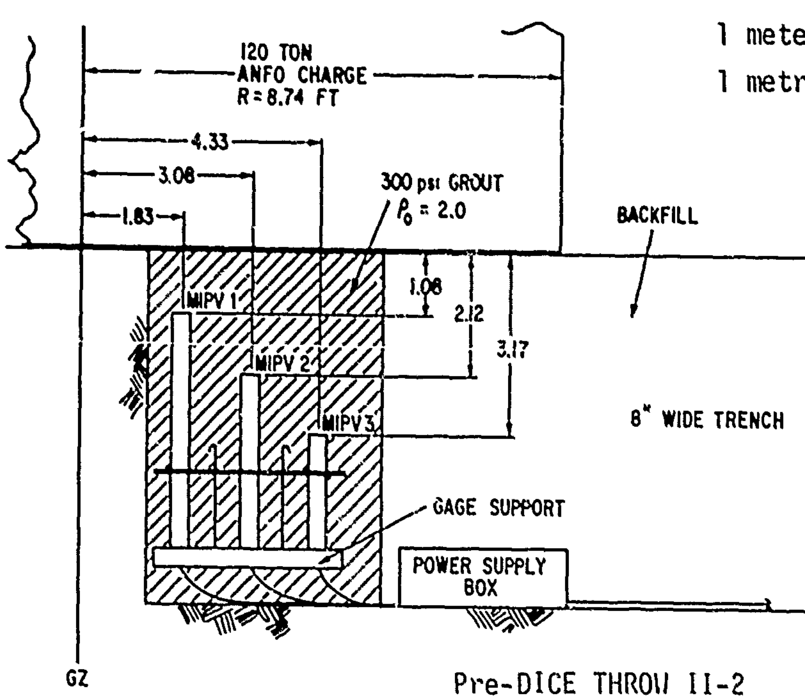


Pre-DICE THROW II-1

1 kPa = 6.89 psi

1 meter = 3.28 ft

1 metric ton = 1.1 ton



Pre-DICE THROW II-2

Figure 2-33. AFWL Gage Placement in Pre-DICE THROW II, Events 1 and 2

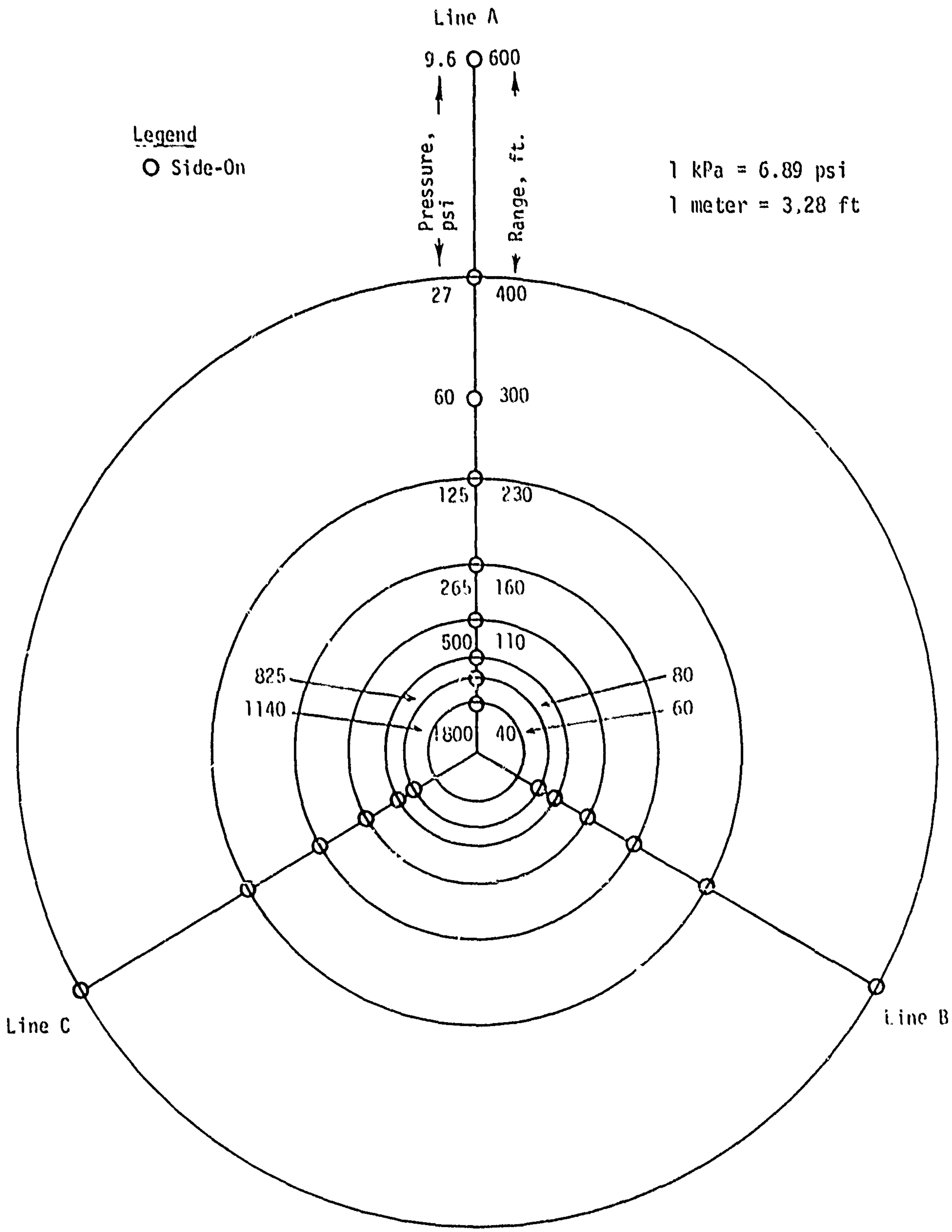


Figure 2-34. BRL Instrumentation Layout, Pre-DICE THROW II, Event 1

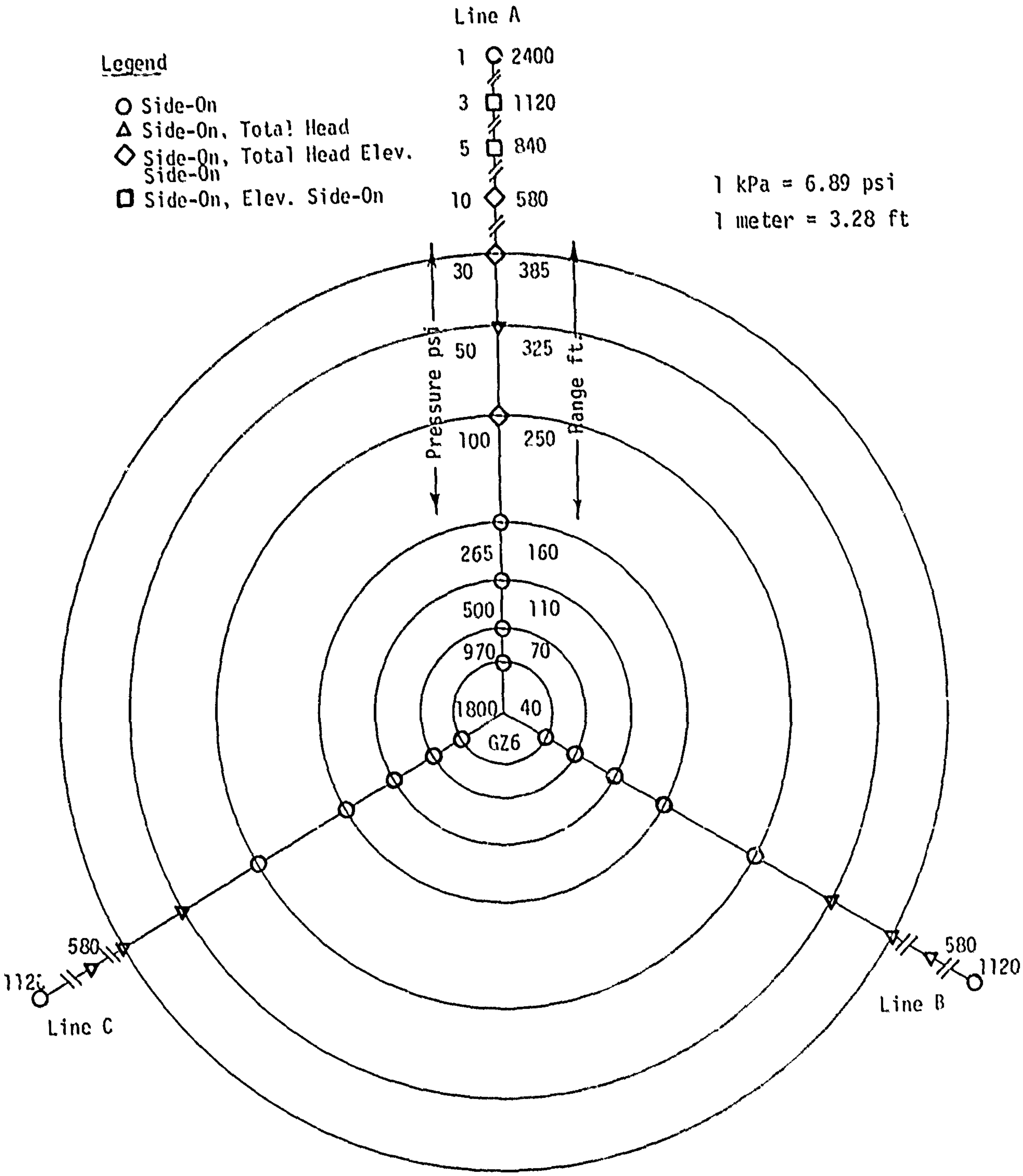


Figure 2-35. BRL Instrumentation Layout, Pre-DICE THROW II, Event 2

motion stations. All measurements were configured to measure the side-on or incident-pressure time histories.

Forty-four channels of instrumentation were recorded on the ANFO event. The channels were divided as follows: (1) twenty-nine side-on at the ground surface; (2) five side-on at 3 feet (0.91 m) above the ground; and (3) ten total-head or stagnation-pressure measurements. The stations located at ground ranges of 40, 70, 110 and 160 feet (12.19, 21.34, 33.53 and 48.77 m) were chosen to compare directly with the results of Event 1. Refer to Figure 2-36 for photographs of the gages and their mounts.

On Event 1, BRL supported the MX Trench Experiment by installing and recording pressure gages to monitor wall static pressure inside and overpressure outside the trenches (refer to MX Trench experiment description for exact locations). Nine gages were mounted inside trench number one, and six others outside the trench. Eight gages were mounted inside trench number two; six gages inside trench number three and six also inside trench number four. Two additional gages were placed near the entrance to trench number four.

5. Canada-Defense Research Establishment Suffield (DRES)/Canadian General Electric Co. (CGE)

   TITLE: TNT Charge Design and Construction (DNA Project No. 160-65, POR #6913)

   PROJECT OFFICERS: Mr. R. Klymchuk and Mr. R. Naylor (DRES)/ Mr. A. Lambert (CGE)

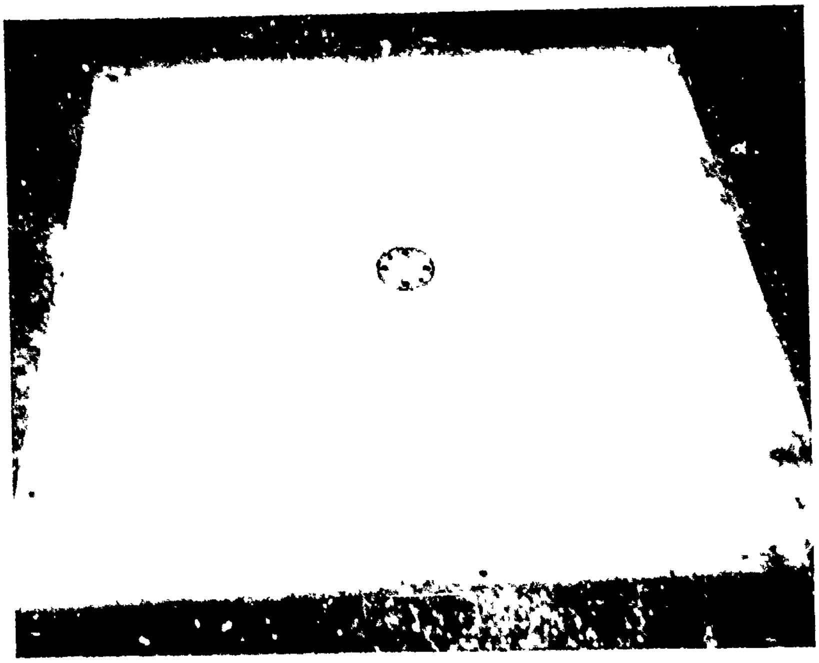
   EXPERIMENT DESCRIPTION: Refer to the section on Charge Descriptions for details concerning this effort.

6. Canada (DRES)

   TITLE: Detonation Velocity Measurements (POR #6913)

   PROJECT OFFICER: Mr. R. Naylor

   OBJECTIVE: Measure the detonation velocity of the TNT charge.



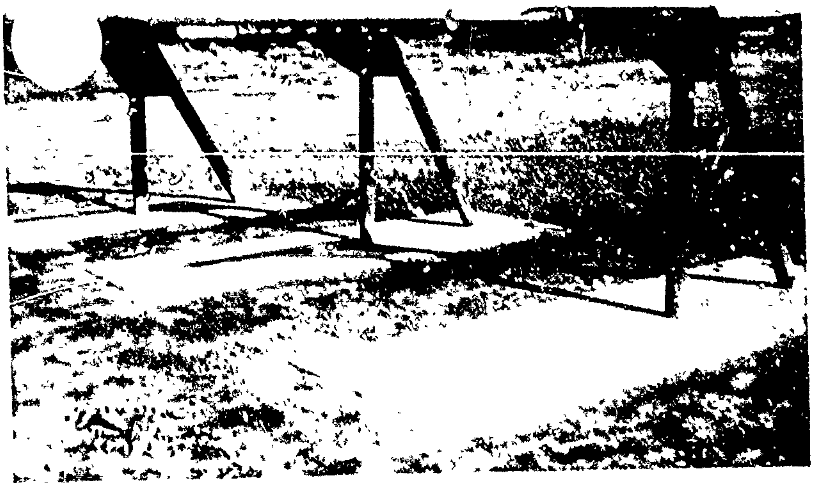


Figure 2-36. Pre-DICE THROW II, Events 1 and 2, BRL Airblast Transducers and Their Mounts

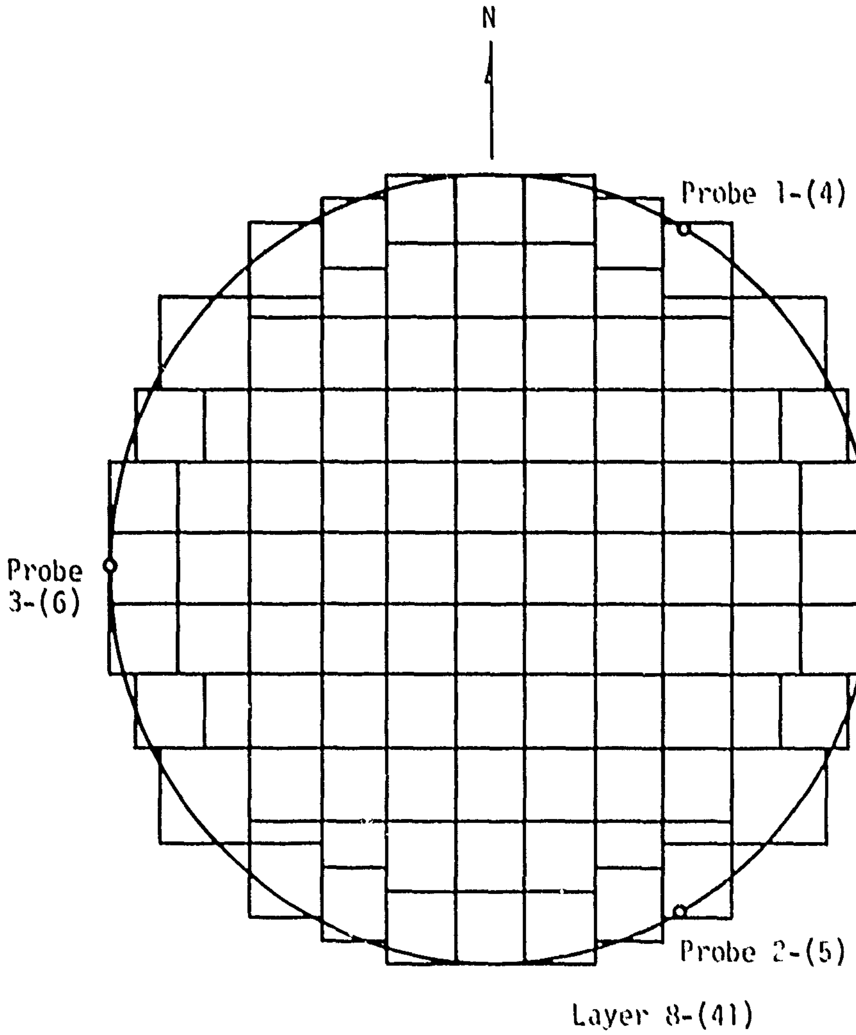
EXPERIMENT DESCRIPTION: (Refer to Table 2.10, and Figures 2-37 and 2-38.) Fifteen ionization pins were placed within the TNT stack during the construction of the charge. Two of the pins were located at the interface between the 16-in. (40.64-cm)-diameter tetryl booster and the TNT blocks. The remaining thirteen pins were equally spaced on the longitudinal circumference of the charge, three on layer 8, six on layer 24, three on layer 41 and one on layer 48.

7. Lawrence Livermore Laboratory (LLL)

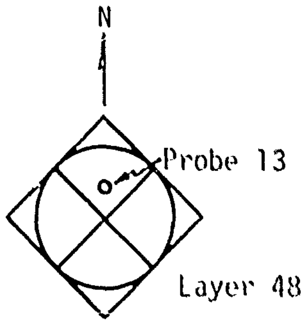
TITLE: 120-Ton (108.9-Metric-Ton) ANFO Charge Explosive Performance (DNA Project No. 160-54)

Table 2-10. Stack and Probe Geometry, Pre-DICE THROW II, Event 2

Probe	Radius		Azimuth	Layer
	(in.)	(cm)	(degrees)	
1	94.28	239.47	4	8
2	94.50	240.03	124	8
3	94.10	239.01	244	8
4	94.25	239.40	4	41
5	94.35	239.65	124	41
6	94.16	239.17	244	41
7	94.50	240.03	4	24
8	96.60	245.36	64	24
9	94.50	240.03	124	24
10	94.50	240.03	184	24
11	96.80	245.87	244	24
12	94.50	240.03	304	24
13	96.50	245.11	19	48
14	8.	20.32		
15	8.	20.32		

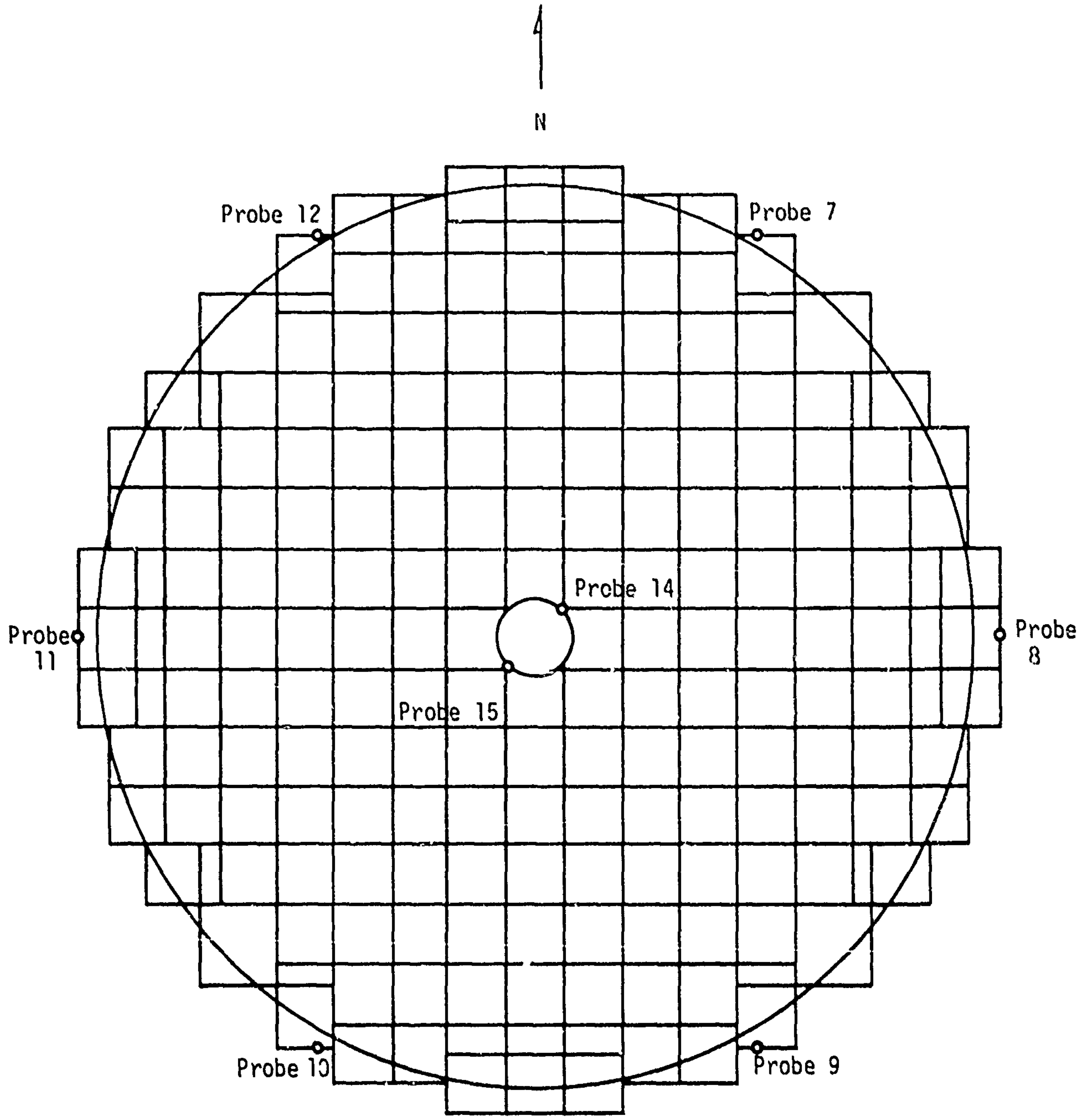


Plan View



Plan View

Figure 2-37. Plan Views of Layers 8, 41 and 48 Pre-DICE THROW II, Event 1



Plan View

Figure 2-38. Plan View of Layer 24, Pre-DICE THROW II, Event 1

PROJECT OFFICER: Mr. M. Finger and Mr. E. Lee

OBJECTIVES: Assess the dynamic performance of the explosive material, and ascertain the simultaneity of the initiators used to detonate the booster column of the ANFO stack.

EXPERIMENT DESCRIPTION: Three 16-in. (40.6-cm)-long rate sticks and one 6-ft (182.9-cm)-long rate stick were embedded in the ANFO stack to record the time the detonation front passed a recording station. The rate sticks consisted of a phenolic rod or substrate with barium titanate $BaTiO_3$ self-generating electric pins mounted at known intervals along the stick. The ratio of pin separation to differential pin time is the detonation velocity; $D = \Delta x/\Delta t$. Refer to Figure 2-39 for rate stick placement.

Each of the three short rate sticks had eight signal pins and a parallel pair of trigger pins. The trigger pin pairs fed individual trigger lines connected to three raster oscilloscopes. The pin signals fed into a single compensated signal line through a diode mixing box. The pin signal line was cascaded to the three raster oscilloscopes. Time-sharing was accommodated with space-separated triggers.

Rate stick No. 1 was 6 in. (15.2 cm) from the booster container, in line with the second booster, and directed in the NE quadrant of the stack. Rate stick No. 2 was 42 in. (106.7 cm) from the booster container, between the fifth and sixth boosters, and also directed in the NE quadrant. Rate stick No. 3 was in the loose ANFO, filling the void between the outer and inner cardboard material supporting the high-explosive ring charges. The last pin on this rate stick was 10.5 in. (26.7 cm) below the top 20 ft (6.1 m) of the booster container. This allowed overlap of the last pin on rate stick No. 2 with the first pin on rate stick No. 3. The overlap was used to correlate signal identification. Between rate stick No. 1 and rate

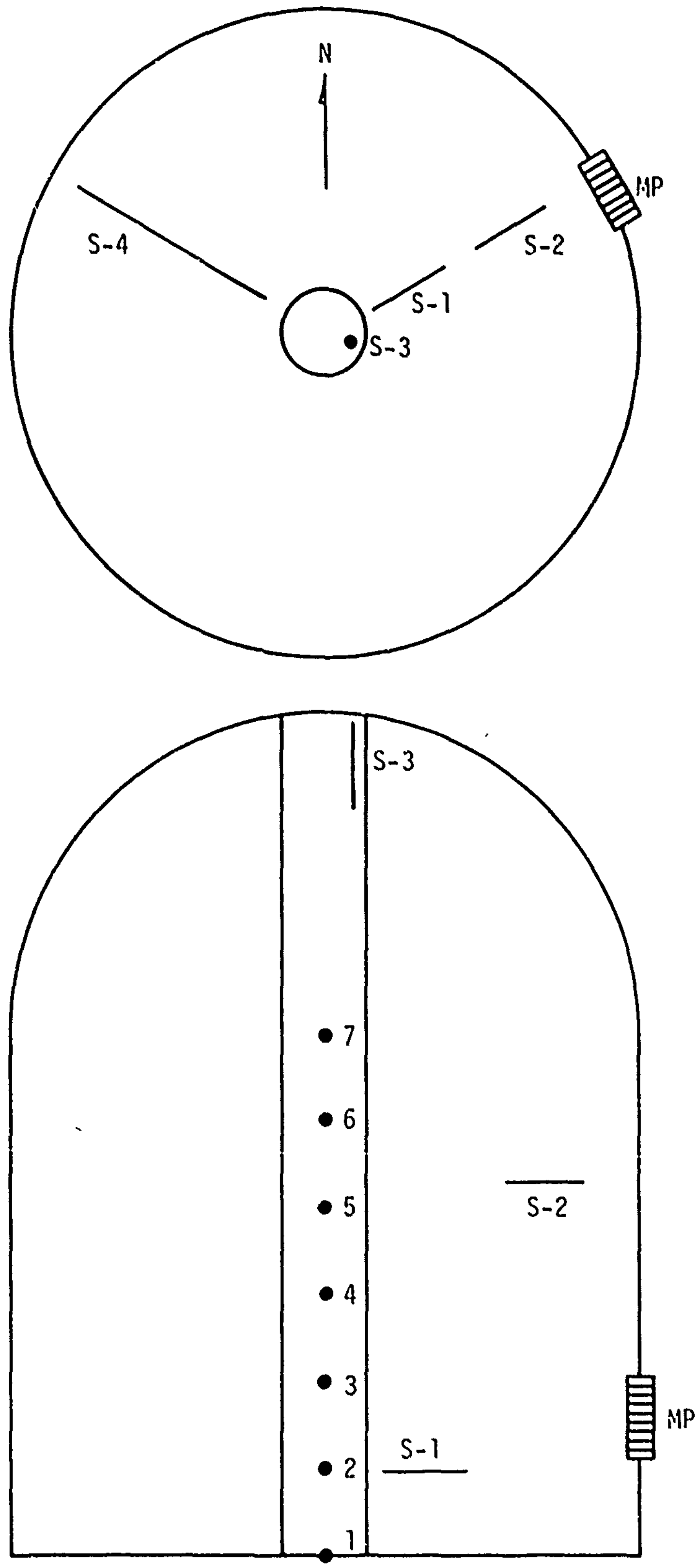


Figure 2-39. Plan and Side Views of Embedded Rate Sticks and Magnetic Probe, Pre-DICE THROW II, Event 2

stick No. 2, where there was no signal overlap, continuity was accomplished by starting a Time Interval Meter (TIM) with the trigger pulse from rate stick No. 1 and stopping the TIM with the trigger pulse from rate stick No. 2. Thus, the three separate rate sticks were effectively joined in time. Table 2-11 shows the individual pin spacing for each rate stick.

The magnetic probe used on the Pre-DICE THROW II ANFO stack was designed to produce a pulse shape corresponding to the particle velocity of the embedded plate. For this reason the probe had an aspect ratio of 2:1, and a separation from the plate to the sense coil/magnet face of 2 in. (5.08 cm). The magnet, a nominal 0.98 x 0.98 in. (2.5 x 2.5 cm) right-circular barium ferrite, 3700 gauss cylinder, was calibrated prior to being installed on the shot. A nine-turn circular coil serving as the sensing element had a mean radius of 135.4 mm. This coil size required a large plate size which turned out to be 27 in. (68.6 cm) on a side.

Table 2-11. Measured Rate Stick Pin Spacing

Pin Numbers	Rate Stick No. 1 Spacing mm	Rate Stick No. 2 Spacing mm	Rate Stick No. 3 Spacing mm
1-2	58.4	57.9	55.2
2-3	57.0	57.4	54.8
3-4	57.6	57.4	53.9
4-5	57.7	57.6	58.4
5-6	57.6	57.3	55.6
6-7	57.5	57.0	65.5
7-8	57.9	57.8	52.2
1-8	403.7	402.4	343.4*

*Spacing for pins 1 through 7

The probe was originally intended to be buried in the ANFO stack. However, due to unforeseen circumstances, the rectangular stacking arrangement was abandoned and the probe was secured to the NE stack perimeter about 5 ft (1.5 m) off the ground. The rear side of the plate was butted against the overhanging bags of explosive, and the voids were filled with loose ANFO. This arrangement proved to be very satisfactory since the driver explosive appeared homogeneous and the large radius of curvature gave a one-dimensional aspect to the experiment. In all, approximately 250 lbs (113.40 kg) of explosive were used for the appendage with an estimated density of 0.84 g/cc.

Two coaxial lines, a compensated RG-331/U signal line and an RG-213/U trigger line, connected the probe to the recording equipment. Four barium titanate trigger pins at the corners of the embedded plate were connected in parallel to feed the trigger line. The trigger line was terminated at a Tektronix Type 556 dual-beam oscilloscope and a Type 7912 transient digitizer. The trigger pins extended into the driver explosive a distance sufficient to overcome the difference in propagation velocity between RG-213/U cable and RG-331/U as well as providing sufficient run-up to properly frame the record.

Signal and trigger lines were calibrated using a loop-around technique which amounted to a quality time-domain reflectometer. With the loop-around technique half-microsecond wide, 0.4-volt square-wave calibration signals were sent down one line and returned on another. The compensators used on the signal lines reduced the amplitude of the pulses by preserving phase delay giving an effective rise time of 10 ns over a cable length of 5500 ft (1676.40 m).

8. Naval Surface Weapons Center (NSWC)

TITLE: 120-Ton (108.9-Metric Ton) ANFO Charge Design and Stacking Supervision (DNA Project No. 160-64)

PROJECT OFFICERS: Mr. J. Petes and Mr. M. Swisdak

EXPERIMENT DESCRIPTION: Refer to the section on Charge Descriptions for details pertaining to this effort.

9. Naval Weapons Evaluation Facility (NWEF)

TITLE: Aircraft Component Experiment (DNA Project No. 160-69)

PROJECT OFFICER: Mr. P. Hughes

OBJECTIVE: Obtain preliminary information on the structural response of an instrumented F-4 wing trailing-edge-flap-panel to the blast, produced by Pre-DICE THROW II, Event 2. The data on this test will be used in planning the configuration and the instrumentation requirements for the A-4C Aircraft test specimen which will be exposed to the DICE THROW blast.

EXPERIMENT DESCRIPTION: Refer to Figures 2-40, 2-41 and 2-42. The test article was mounted on two vertical poles located

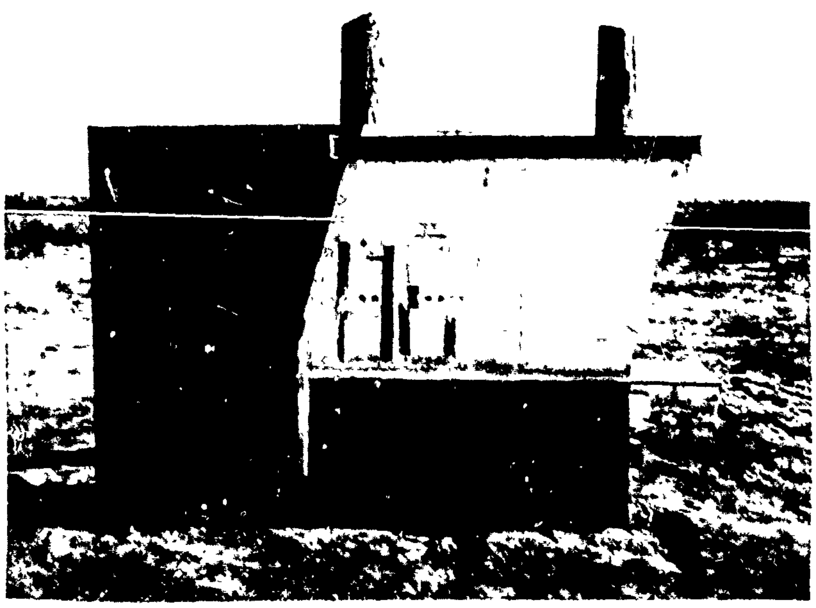


Figure 2-40. Pre-DICE THROW II, Event 2 NWEF Aircraft Component Experiment

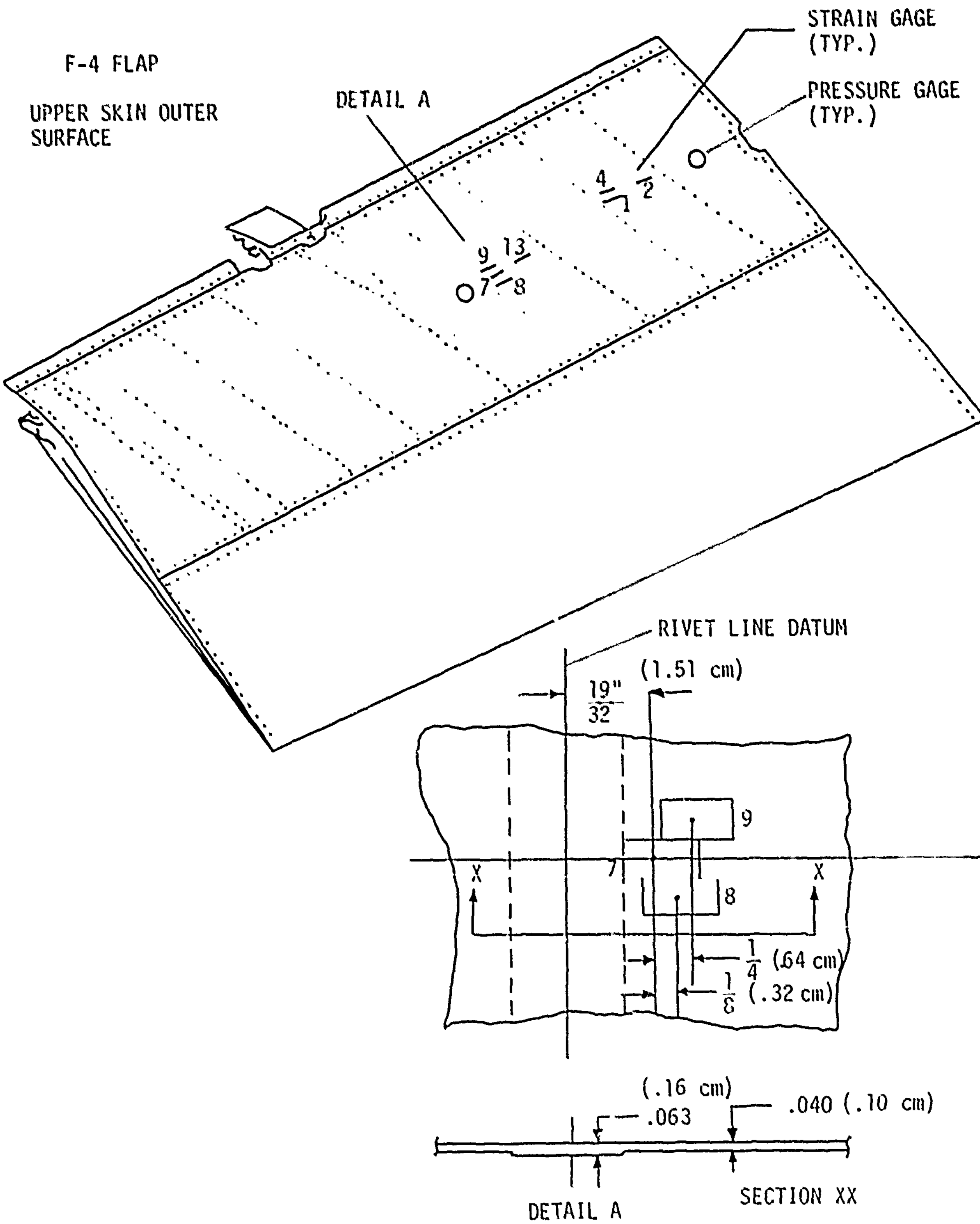


Figure 2-41. NWEF Instrumentation Location Diagram, Pre-DICE THROW II

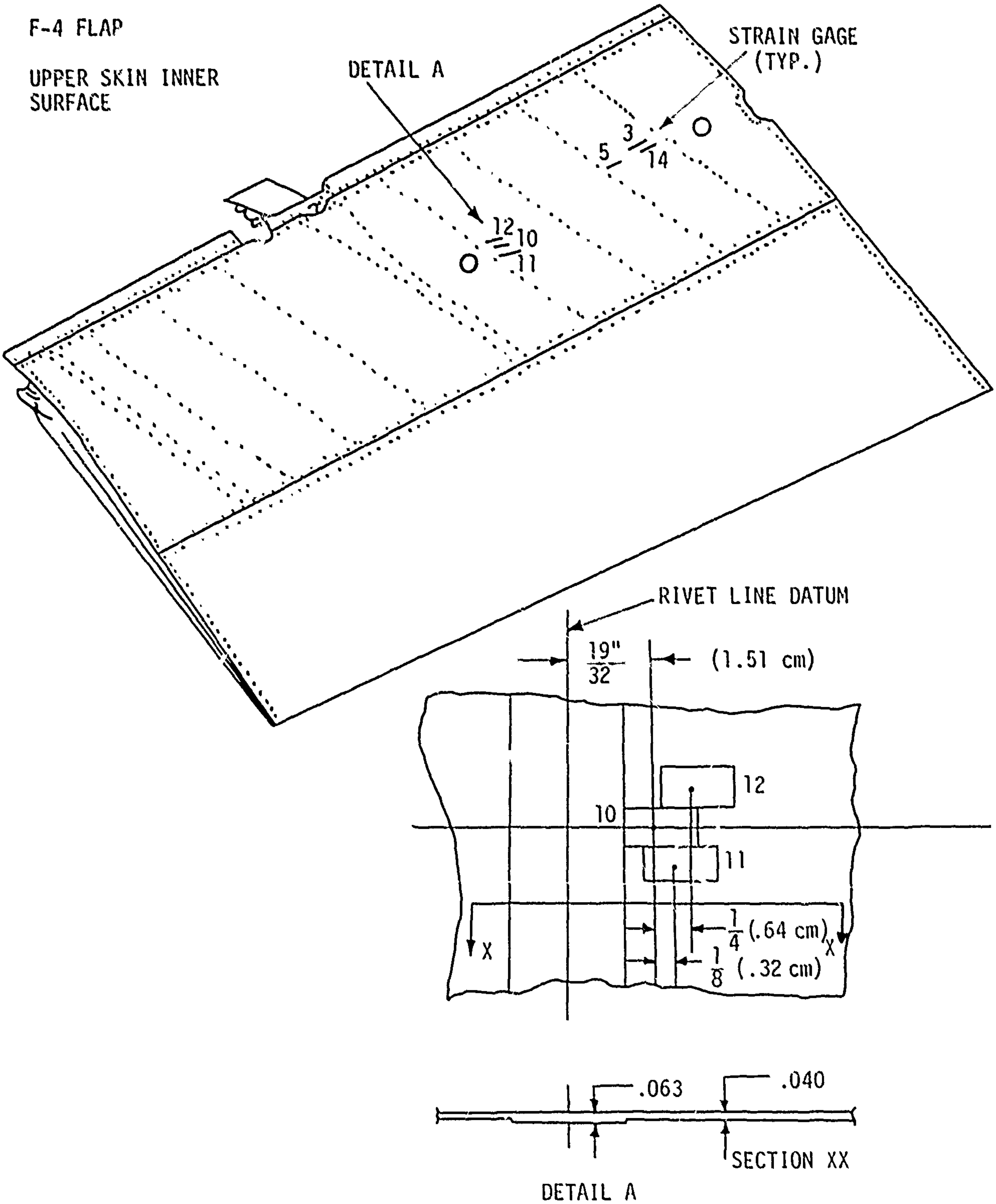


Figure 2-42. NWEF Instrumentation Location Diagram, Pre-DICE THROW II

at the 1000-ft (304.80-m) range (3.7 psi (25.5 kPa)). To minimize edge effects, plywood panels were installed flush with the flap panel. Two smaller panels were instrumented with strain gages. These gages (Figures 2-41 and 2-42) were installed on the upper-skin outside and inside surfaces as well as on the web of the rib which made up the outboard boundary of panel number one. Pressure gages were also installed to monitor the overpressure at the panel surface.

10. Strategic Air Command (SAC)

TITLE: SAC Electro-Optical Viewing System (EVS) Experiment (DNA Project No. 160-50)

PROJECT OFFICERS: Maj. B. Stephan and Capt. J. Riggs

OBJECTIVES: Determine the usefulness of the B-52 EVS as a damage assessment device and provide system operation data.

EXPERIMENT DESCRIPTION: Two B-52 aircraft from K.I. Sawyer Air Force Base, equipped with the EVS (steerable low-light-level T.V. and infrared scanners) and video recorders participated on each event. They were prepositioned on a synchronized elliptical flight path that crossed the ground zeros at nine-minute intervals. Low-altitude passes were made over the ground zero of each event to record the ambient signature, the actual detonation and changes in the crater infrared-signature over time. Operating altitudes varied from 2000 ft (609.60 m) AGL to 500 ft (152.40 m) AGL with track offsets of 0 - 2000 ft (0 - 609.60 m) from the ground zeros.

11. Space and Missile Systems Organization (SAMSO)/TRW Systems Group (TRO)/The Ralph M. Parsons Co./Karagozian and Case

(a) TITLE: MX Debris Collectors (Bins and Barriers) (DNA Project No. 160-55)

PROJECT OFFICER: Maj. D. Gage (SAMSO)/(K&C)

OBJECTIVE: Study debris buildup in scaled MX land-mobile entry ways.

EXPERIMENT DESCRIPTION: (Refer to Figures 2-43 and 2-44 and Pre-DICE THROW II-1 Debris and Trench Tests Final Report, 6 November 1975, Karagozian and Case.) The Debris Test was located in the second 120-degree sector clockwise from the main free-field gage line as indicated in Figure 2-26. The test consisted of three different types of collectors:

1. Bins placed flush with the ground surface to establish the amount of debris entrapment.
2. Barriers placed flush or above ground to obtain debris profiles around typical structures.
3. Control pads to obtain free-field debris measurements within the area of the bins and barriers.

Figure 2-43 shows the placement design of these test articles within the 120-degree sector. The experiment consisted of 13 concrete bin structures and 13 concrete barrier structures placed along arcs at radii of 100 and 120 feet (30.48 and 36.58 m), and 27 free-field steel collector pads set flush with the ground throughout the Debris Test area.

The bins were 20 in. (50.80 cm) deep, 12 in. (30.48 cm) wide, and various lengths with 6-in. (15.24-cm) thick reinforced concrete bottoms and walls. The barriers were open ended channels 12 in. (30.48 m) wide and various lengths and depths with 6-in. (15.24 m) thick reinforced concrete bottoms and walls. The collector pads were 18- by 18-in. (45.72- by 45.72-cm) square 10-gage steel plates.

The bins were all placed with the long axis radial to ground zero and top of concrete flush with the surrounding ground surface. The barriers were placed with the open end of the channel at various angles and at different depths of burial, depending upon their angular alignment. The bariers were anchored to the ground. Refer to the photographs in Figure 2-44.

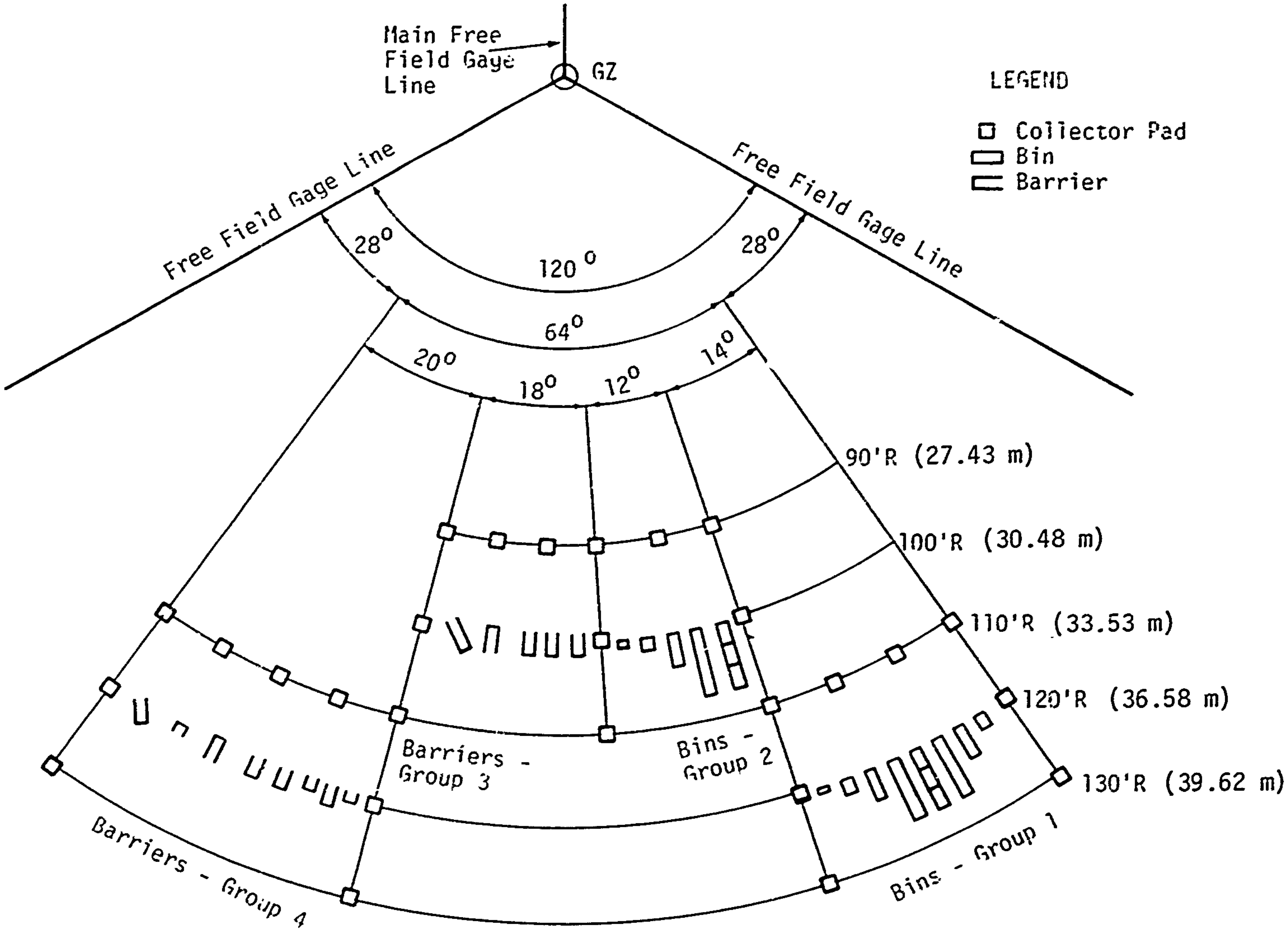
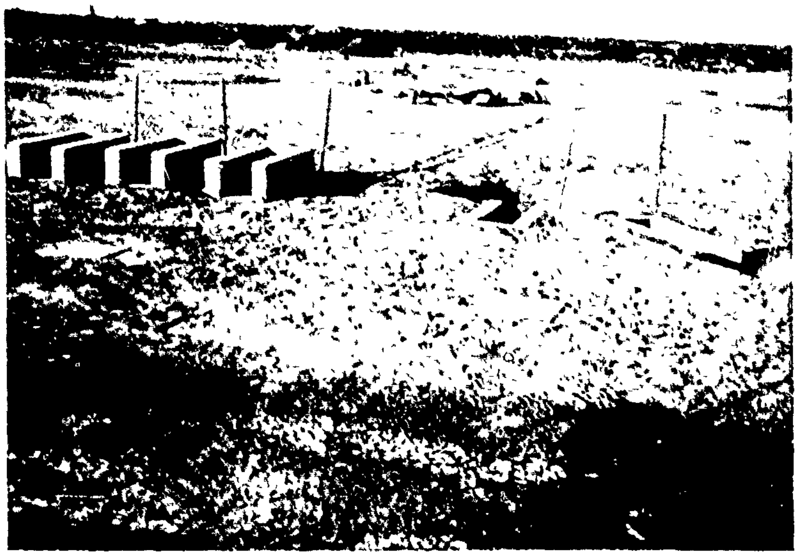


Figure 2-43. MX Debris-Collection Experiment Layout, Pre-DICE THROW II, Event 1



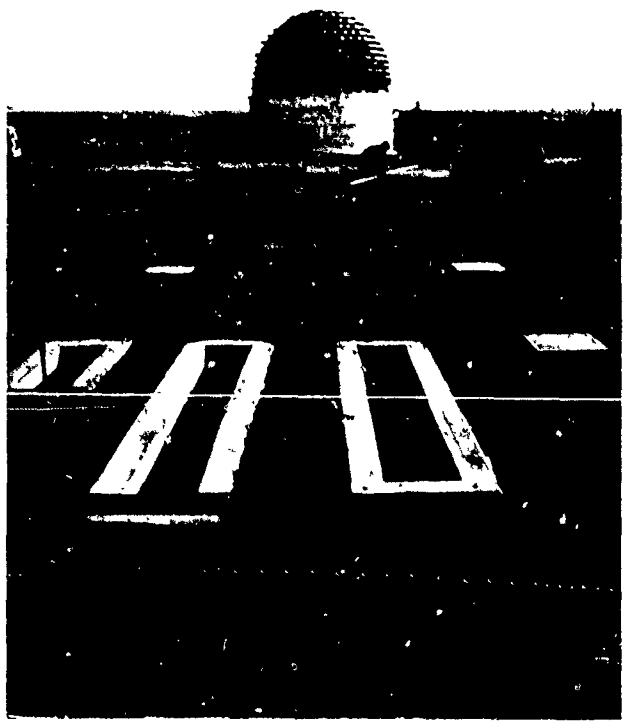


Figure 2-44. MX Bins (Top Photo), Barriers (Bottom Photo), and Collector Pads, Pre-DICE THROW II, Event 1

(b) TITLE: MX Trench Test (Project No. 160-56, POR #6906)

PROJECT OFFICER: Maj. D. Gage (SAMSO/K&C)

OBJECTIVE: Determine the response of soft tunnels and measure viscous flow inside extended pipes when subjected to explosive airblast loading.

EXPERIMENT DESCRIPTION: (Refer to Figures 2-45 through 2-48) The Trench Test was located (as shown in Figure 2-26) in the first 120-degree sector clockwise from the main gage line. The test consisted of the following five items:

Trench 1. A radially-placed open-ended trench, 500 ft (152.40 m) long and extending in as close to ground zero as possible.

Trench 2. A tangentially-placed closed-ended trench, 500 ft (152.40 m) long and extending into the predicted 1000-psi (6894-kPa) station.

Trench 3. A radially-placed open-ended trench, 250 ft (76.20 m) long extending to within 250 ft (76.20 m) of ground zero.

Trench 4. A small-diameter radially-placed open-ended trench, 250 ft (76.20 m) long extending to within 250 ft (76.20 m) of ground zero.

T-Junction. A chamber vented to the surface.

The four trenches and the T-junction were placed as shown in Figure 2-45. Trenches 1 and 2 each simulated a soft trench (simulating failure) for the first 250 ft (76.20 m) and hard trench (survivable) from 250 to 500 ft (76.20 to 152.40 m). Trenches 3 and 4 were both hard trenches. Trenches 1, 2 and 3 were fabricated using 24-in. (60.96-cm)-diameter steel pipe with 0.25- and 0.283-in. (0.64- and 0.283-cm) wall thickness. Trench 4 was fabricated with 6-5/8-in. (1.59-cm)-diameter steel pipe with 10-gage wall thickness.

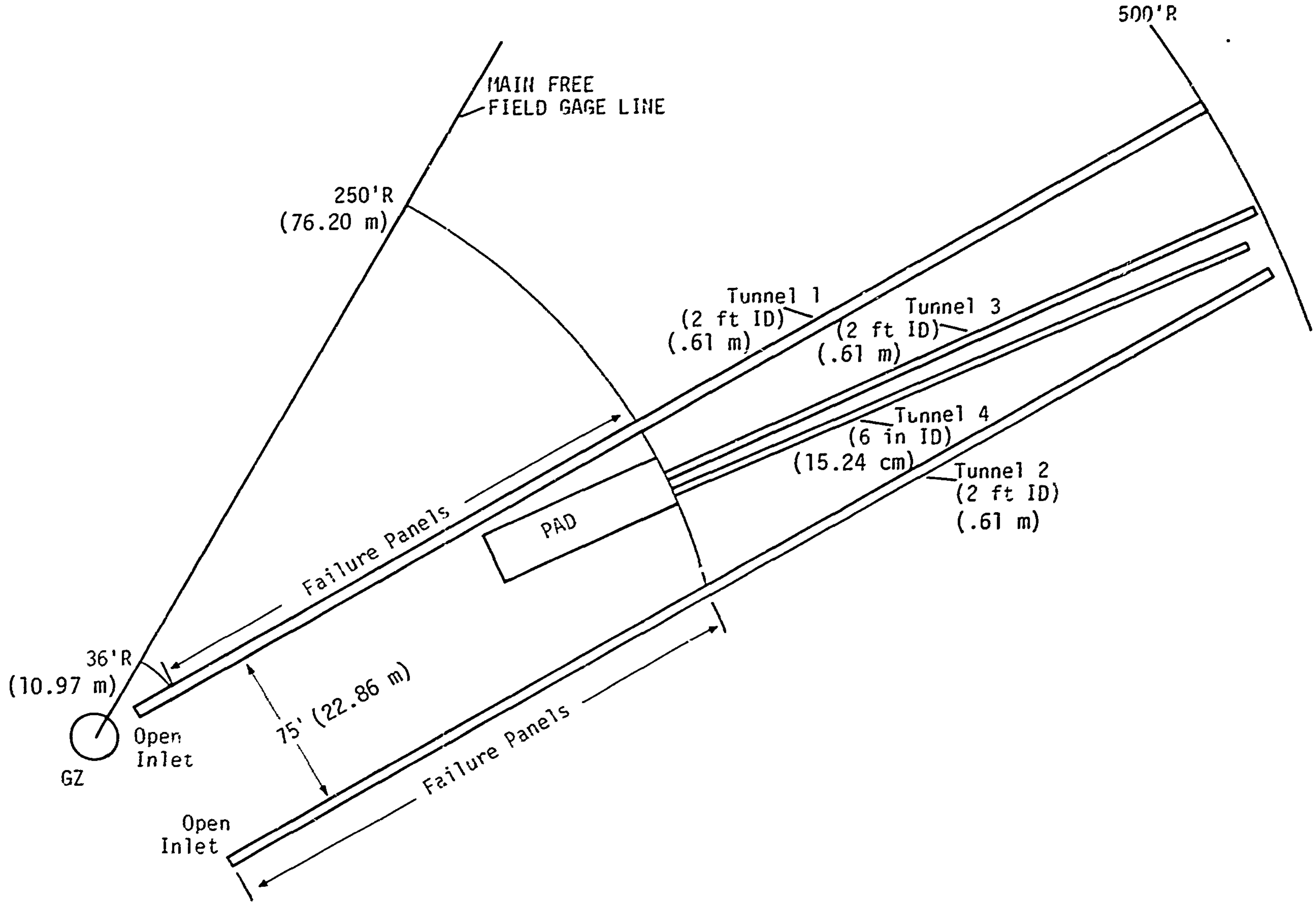


Figure 2-45. MX Trench Test Layout, Pre-DICE THROW II, Event 1

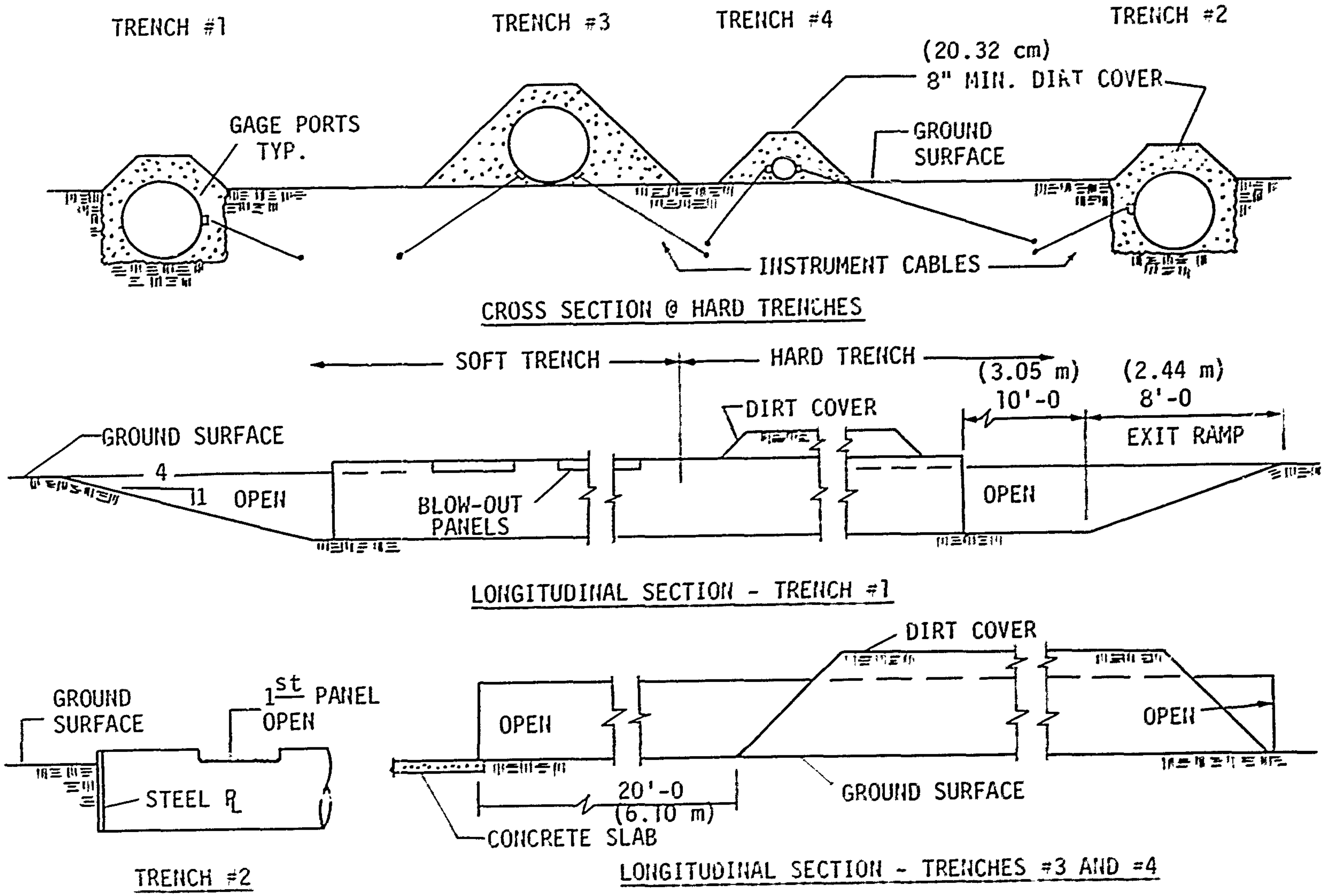


Figure 2-46. Trench Test Details, Pre-DICE THROW II

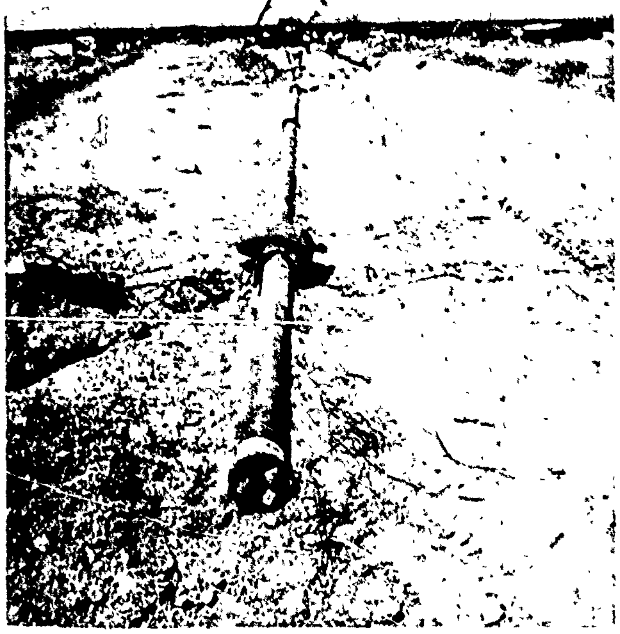


Figure 2-47. MX Trenches Being Readied for Instrumentation Hookup, Pre-DICE THROW II

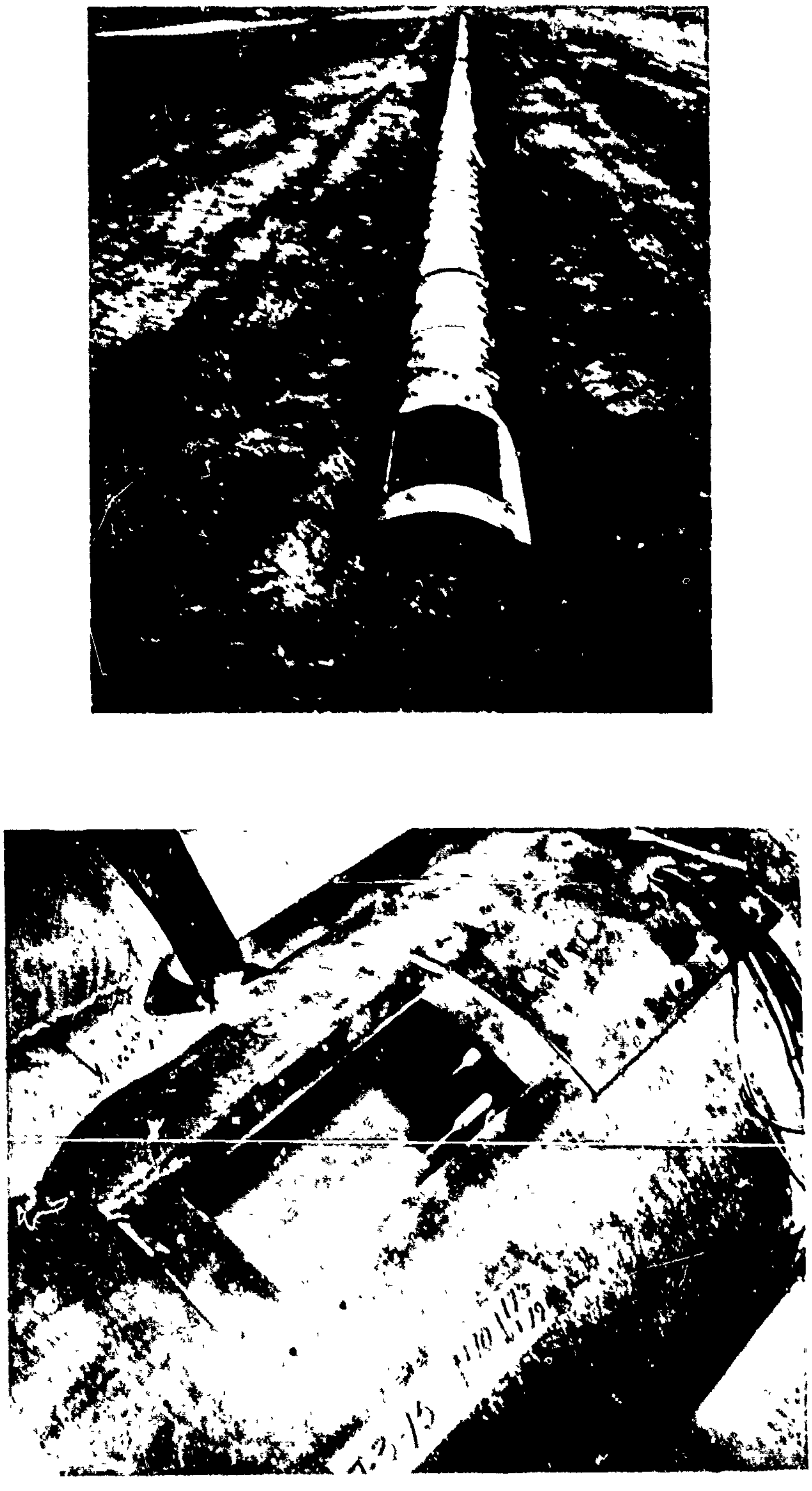


Figure 2-48. MX Trench Test Photographs, Pre-DICE THROW II

The pipes for Trenches 1 and 2 were placed in the ground with the crown 3 in. (7.62 cm) above the ground surface. Trenches 3 and 4 were placed with the invert, flush with the ground. All of the pipe of the hard trenches was covered with 8 in. (20.32 cm) of dirt to minimize pretest heating of the pipe. The placement design for the pipes and the entrance and exit configurations are shown in Figure 2-46. Refer to Figure 2-47 for photographs of two of the trenches.

Trenches 1 and 2 were located in the area where large crater-induced motions were anticipated. To prevent these motions from propagating lengthwise along the steel pipe, sections near the expected crater were cut 10 ft (3.05 m) long and placed with 6-in. (15.24-cm) gaps between sections. At ranges where smaller ground motions were expected longer length sections were used, the sections were anchored, and 6-in. (15.24 cm) gaps were placed between sections out to a range of 250 ft (76.20 m). The two trenches above ground (3 and 4) were anchored to resist asymmetrical airblast loadings.

The soft portions of Trenches 1 and 2 were simulated by cut-out panels placed back in the pipe sections with glass clips for support. The glass clips assured that the panels would be blown out or in by the pressure without being sensitive to variations in peak pressure or impulse magnitudes. Refer to the photograph in Figure 2-48 (top photo).

The trenches were instrumented with pressure transducers and transducers for viscous-flow phenomenology measurements (wall shear-stress, wall temperature and total pressure). Time-of-Response (TOR) gages were placed on soft panels of Trenches 1 and 2. These measurements were made by BRL. Refer to Figure 2-48 (bottom photo).

Each measurement item was given a Measurement Number for identification purposes. Table 2-12 summarizes the measurements installed on each trench test article.

The pressure and temperature gages were mounted in a brass plug that was in turn mounted in a steel block welded to the pipe sections. The brass plugs were each fitted to a block and then shipped to the instrument supplier for mounting of the gage in the plug and later installation into pipe at the test site.

The TOR gage consisted of a breakwire placed between the soft panel and the pipe section at one side of the panel. By laboratory tests it was demonstrated that relative shear-type displacement of 0.075 in. (0.19 cm) broke the wire which then triggered a change in the voltage output of the coder. There were four wires to each coder and six coders per trench. For each trench the output of the coders was sampled at the rate of once per 50 microseconds. Each trench had a separate multiplexer.

Cables were run from each shear-stress, wall-temperature, total-temperature, and total-pressure gage to a vault located between Trenches 1 and 2 for signal conditioning and then on out to the instrumentation vans. Cables were run from each TOR gage to a second vault located clockwise from Trench 2 for multiplexing and then on out to the instrumentation van. The cables for each pressure gage ran directly to the instrumentation van.

(c) TITLE: MX Structures Test (DNA Project No. 160-57, POR #6907)

PROJECT OFFICER: Maj. D. Gage (SAMSO/Parsons)

OBJECTIVES: (1) Determine the response mechanism of thick-walled cylinders of low-tensile strength buried with a depth of cover of one-quarter diameter; (2) Compare the response modes and magnitudes of response of cylinders segmented longitudinally by weakened planes with similar

Table 2-12. MX Trench Test Measurement Summary

SAMSO Measurement No.	Measurement Type	Trench No.	Ground Range - Feet(Meters)	Total No. of Gages
1501 thru 1509	Pressure	1	36 - 490(10.97 - 149.35)	9
875 thru 876	Time of Response		45 - 242.6(13.72 - 73.94)	22*
1510 thru 1517	Pressure	2	112 - 490(34.14 - 149.35)	8
971 thru 994	Time of Response		74.25 - 248.56(22.63 - 75.76)	24
001 thru 004	Shear Stress	3	325 - 490(99.06 - 149.35)	4
009 010	Wall Temperature		385 - 490(117.35 - 149.35)	2
013 014	Total Temperature		385(117.35)	2
015 016	Total Pressure		385(117.35)	2
Additional	Wall Temperature		250(76.20) 325(99.06)	2 1
	Total Temperature		250(76.20) 385(117.35)	2 1
	Total Pressure		385(117.35) 491(149.66)	1 1
005 thru 008	Shear Stress	4	325 - 490(99.06 - 149.35)	4
001 012	Wall Temperature		385 - 490(117.35 - 149.35)	2
Additional	Wall Temperature		325(99.06)	1
1530 1531	Pressure	T-Junction	250(76.20)	2

*NOTE: 2 TOR gages deleted by welding closed the first 6 panels in Trench No. 1.

monolithic concrete cylinders; (3) Determine the effect of variation of backfill compaction, overpressure, concrete strength, and wall thickness to diameter ratio on shallow-buried thick-walled cylinder response; (4) Investigate the effect of footing width on footing penetration and arch barrel response for arches in the 200- and 300-psi (1378- and 2068-kPa) overpressure regions.

EXPERIMENT DESCRIPTION: Refer to The Ralph M. Parsons Co. Report #POR 6907, Pre-DICE THROW II-1 Structures Experiments and Figure 2-49.

Twenty-nine structures were buried at ranges from ground zero corresponding to the calculated 600-, 300-, 200- and 100-psi (4136-, 2068-, 1378- and 689.4-kPa) pressures. Their longitudinal axes were perpendicular to their radii from ground zero as shown in Figure 2-49. All structures were buried with 1 ft (0.30 m) of cover corresponding to approximately a 1/4-diameter depth of burial, and the fill over each structure was finished flush with the surrounding grade.

The structures were fabricated from nominal 4-ft (1.22-m)-diameter commercial concrete pipe reinforced with elliptical cages of steel wire. This pipe is conventionally used with the elliptical reinforcement cages oriented to resist positive bending (internal surface-cracking) at the crown and invert and to resist negative bending (external surface-cracking) at the springlines for vertical loads on the pipe. When so placed, the reinforcing is most effective for resisting airblast-induced (vertical) ground shock and least effective for resisting direct-induced (horizontal) ground shock. When rotated 90 degrees from the conventional placement, the reinforcement is least effective for resisting vertical ground shock but most effective for resisting horizontal ground shock.

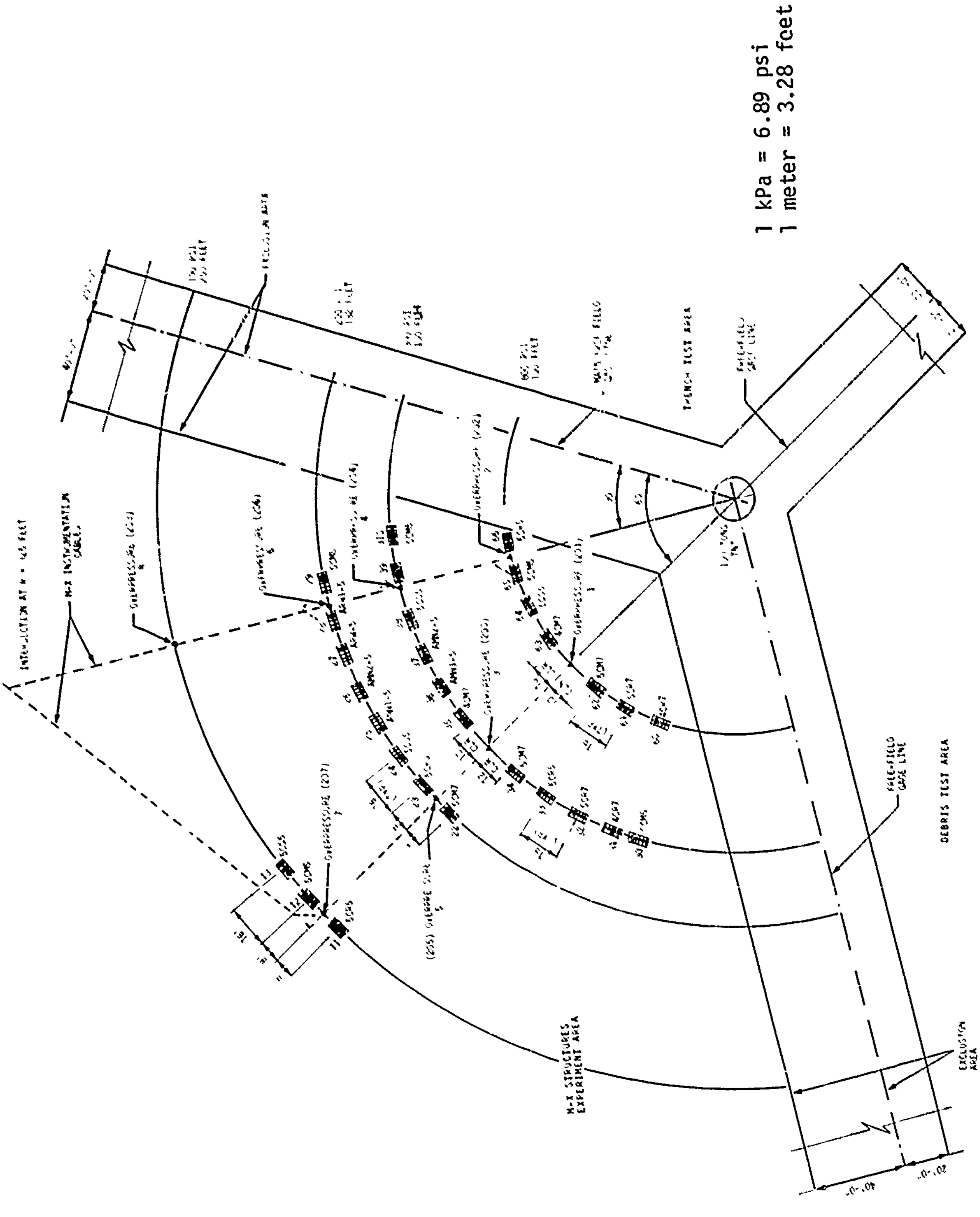


Figure 2-49. MX Structures Experiment Test-Bed Layout - Pre-DICE THROW II

Cylindrical test articles were placed in both the conventional and rotated reinforcing cage orientation, designated at Type R and Type M cylinders, respectively, to compare the effects of conventional and reduced-moment capacity on cylinder response to vertical ground-shock. Additional cylindrical test articles, with reinforcing as for the M configuration, were notched in the intrados and extrados by longitudinal saw-cuts at the crown and at 45 degrees either side of the crown cuts, and designated as Type S. The saw cuts were 1 in. (2.54 cm) deep to produce sections of reduced flexural resistance while still maintaining shear resistance. The steel-strip filler detail was intended to provide full contact for compression transfer at each notch; the degree of contact achieved varied along each strip but this had no discernible effect on the Type S cylinder response. Arch test articles were half-cylinders cut from full pipe sections, which were tested in both the R and M reinforcing configurations.

For unambiguous reference, the cylinders were coded according to their nominal wall thickness, reinforcement orientation, wall notching, and nominal concrete strength, and the arches were coded according to their reinforcement orientation and footing width, as listed in Table 2-13.

The backfill and cylinder bedding material was sand. The sand compaction was measured according to ASTM-D-1557. All cylinders were founded on beds of sand compaction to a design value of 95 percent. The compacted sand was cut to fit the cylinder extrados and checked with a template to provide 90 degrees of full bearing. The arch footings were cast-in-place on compacted native soil. The backfill for all test articles was sand with a design compaction of 95 percent, except for test articles 310 and

Table 2-13. MX Structures Coding

	Location No.	Wall Thickness (in.)	Wall Thickness (cm)	Type	Nominal f'_c (KSI)	Nominal f'_c (kpascal)	Footing Width (in.)	Footing Width (cm)	Code
Cylinders	12, 29, 30, 310, 65	5	12.70	M	5	3.45×10^4	-	-	5CM5
	11, 23, 33, 66	5	12.70	R	5	3.45×10^4	-	-	5CR5
	13, 24, 38, 64	5	12.70	S	5	3.45×10^4	-	-	5CS5
	22, 34, 62	5-3/4	14.61	M	7	4.83×10^4	-	-	5CM7
	32, 61	5-3/4	14.61	R	7	4.83×10^4	-	-	5CR7
	35, 63	4-1/4	10.80	M	7	4.83×10^4	-	-	4CM7
	31, 60	4-1/4	10.80	R	7	4.83×10^4	-	-	4CR7
Arches	26, 37	5	12.70	M	5	3.45×10^4	9	22.86	AMN2
	25, 36	5	12.70	M	5	3.45×10^4	13	33.02	AMN1
	27	5	12.70	R	5	3.45×10^4	17	43.18	ARW
	28	5	12.70	R	5	3.45×10^4	13	33.02	ARN1

30, which has backfill design compactions of 85 and 75 percent, respectively. Field check of compaction was made by the sand-cone method. Refer to Figure 2-50 for photographs of the structures.

End closures for the test articles were reinforced concrete slabs 58 in. (147.32 cm) square for the cylinders, and 29 in. (73.66 cm) high by 58 in. (147.32 cm) wide for the arches. The end closures were designed for elastic behavior and were placed against, but not fastened to, the test articles in order to minimize their effect on test-article response.

All test articles were instrumented with passive scratch gages which, for the cylinders, recorded the peak change in diameter and, for the arches, recorded the peak vertical displacement of the crown relative to the foundation grade between the arch footings. All cylinders had at least one scratch gage on the vertical diameter, and selected cylinders had scratch gages on the horizontal and 45-degree diagonal diameters as well.

Selected structures, Numbers 12, 28, 29, 34, 35, 39, 62 and 65, were electronically instrumented to obtain the time history of response. This was done with linear variable differential transformers (LVDTs) mounted on the instrumentation strut tubes to read their relative diametral displacement. The mounting consisted of plastic blocks, epoxy-glued, one each to the inner and outer tubes, into which the transducers were screwed. Test article 65 was further instrumented with an accelerometer to obtain the time history of vertical acceleration seen by its crown. All of these test articles were instrumented for vertical, horizontal, and diagonal diametral response, except No. 62, on which diagonal measurement was not made, and No. 28 which was an arch.

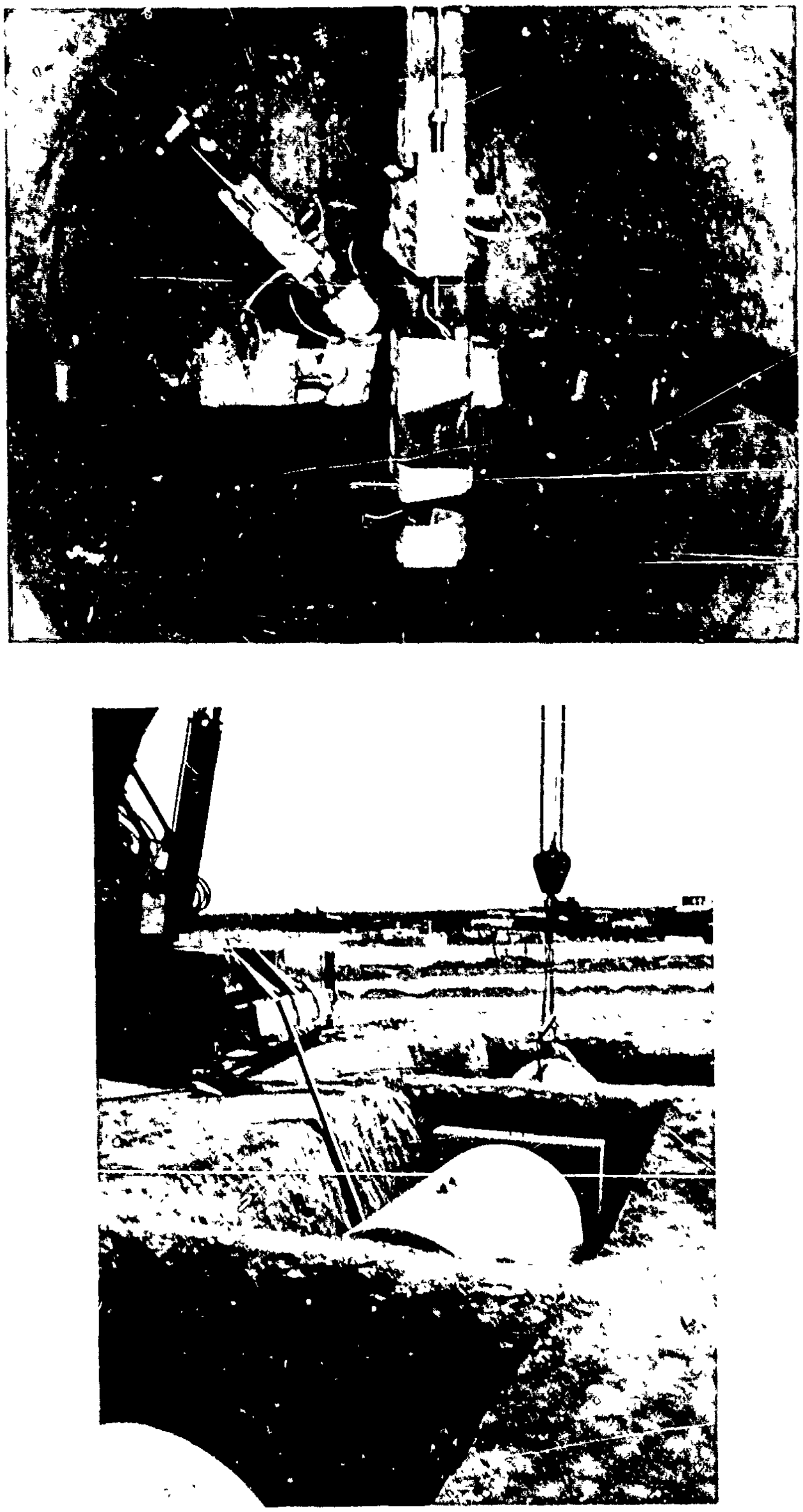


Figure 2-50. Photographs of MX Structures Internal Instruments (Top Photo), Structure Placement (Bottom Photo), Pre-DICE THROW II

Both the scratch-gage set screws and the displacement transducers were placed on faces of the instrumentation struts, which were perpendicular to the longitudinal axes of the test articles, and the transducers were mounted in the plane of the strut neutral axis. This transducer placement minimized spurious readings caused by possible transverse (radial to the test articles) vibration of the instrumentation struts.

Eight overpressure gages were mounted in two lines, 30 degrees apart, two each at the calculated 600-, 300-, 200- and 100-psi (4136-, 2068-, 1378- and 689.4-kPa) ranges. The overpressure gages, and the electronic instrumentation of the test articles, were installed and monitored and their data reduced by Sandia Laboratories. All electronic data were recorded on tape, then digitized before plotting.

12. Sandia Laboratory Albuquerque (SLA)

(a) TITLE: Optical Measurements (DNA Project No. 160-51)

PROJECT OFFICER: Mr. D. Thornbrough

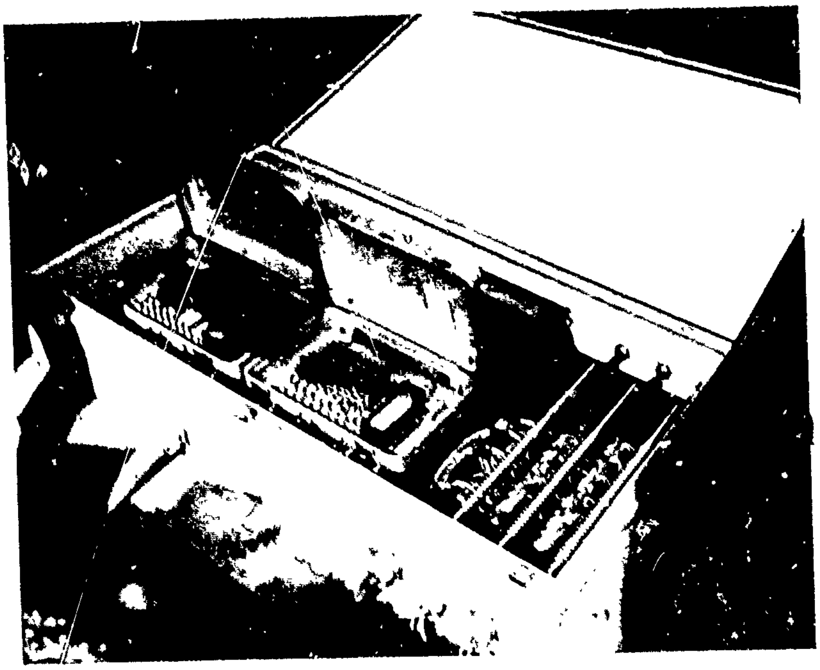
OBJECTIVE: Evaluate the performance of the YSR and Super Suitcase optical detection devices.

EXPERIMENT DESCRIPTION: (Refer to Figure 2-51) One Super Suitecase was fielded on Event 1 and two Super Suitcases and a YSR Suitcase were fielded on Event 2. These devices were placed approximately 14,000 ft (4267.20 m) from GZ on both events.

(b) TITLE: Free-Field Airblast, Stress, Ground Motion and Arrival Time Measurements (DNA Project No. 160-52)

PROJECT OFFICER: Mr. D. Breding

OBJECTIVE: To measure stress, motion and arrival time in the near-surface earth media, and airblast in the near-source region.



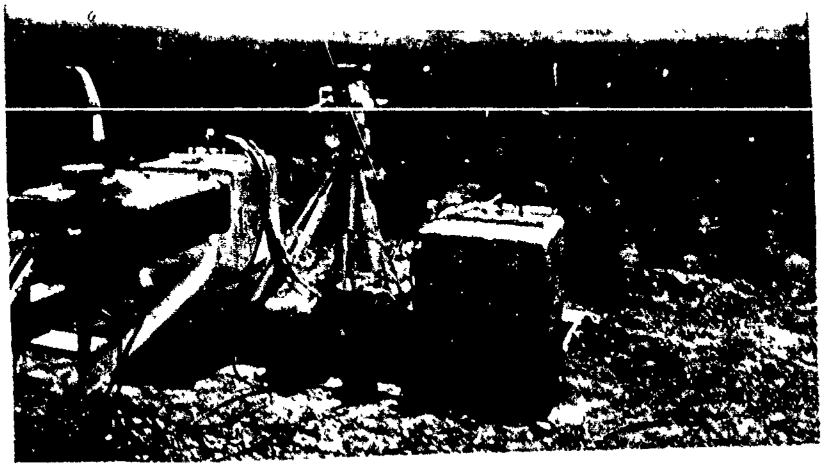


Figure 2-51. SLA Super Suitcase Experiment, Pre-DICE THROW II

EXPERIMENT DESCRIPTION: (Refer to Figures 2-52, 2-53, 2-54, 2-55 and 2-56) Measurements were recorded at three locations where airblast was predicted to be 25,000, 8,000 and 1,000 psi ($1.72x10^5$, $5.52x10^4$ and $6.89x10^3$ kPa). The gages were prepared in two versions: one a fluid-coupled metal plunger and lithium niobate crystal, and the other involving direct mechanical coupling. The fluid-coupled model was used at all three stations and the mechanically coupled model only at the predicted 8-ksi ($5.52x10^4$-kPa) station. A fifth gage was included at the predicted 25-ksi ($1.72x10^5$-kPa) level. It was a commercially available gage with a carbon sensor, manufactured by Dynasen, Inc., Goleta, California. This gage was added to provide a comparison with the lithium niobate gage being developed.

SLIFER (Shorted Location Indicator by Frequency of Electrical Resonance) time-of-arrival measurements were made on the Pre-DICE THROW II events. The measurement method has been used successfully at the Nevada Test Site for several years to aid in determining time-of-arrival contours, although application to high-explosive detonations with greater resolution is a more recent development.

For the Pre-DICE THROW II-1 event, two SLIFER's were installed on the 306-degree azimuth at depths of approximately 0.5 and 4.5 ft (0.15 and 1.37 m). Their radial length was approximately 63 ft (19.20 m). Frequency versus shorted-length calibration data was processed to determine shock position as a function of time. These data will be used to supplement the arrival-time contours constructed by WES.

Stress measurements were made at five ranges with several types of sensors located at each location. The five distances chosen were at the predicted 15-, 8-, 3-, 1-,

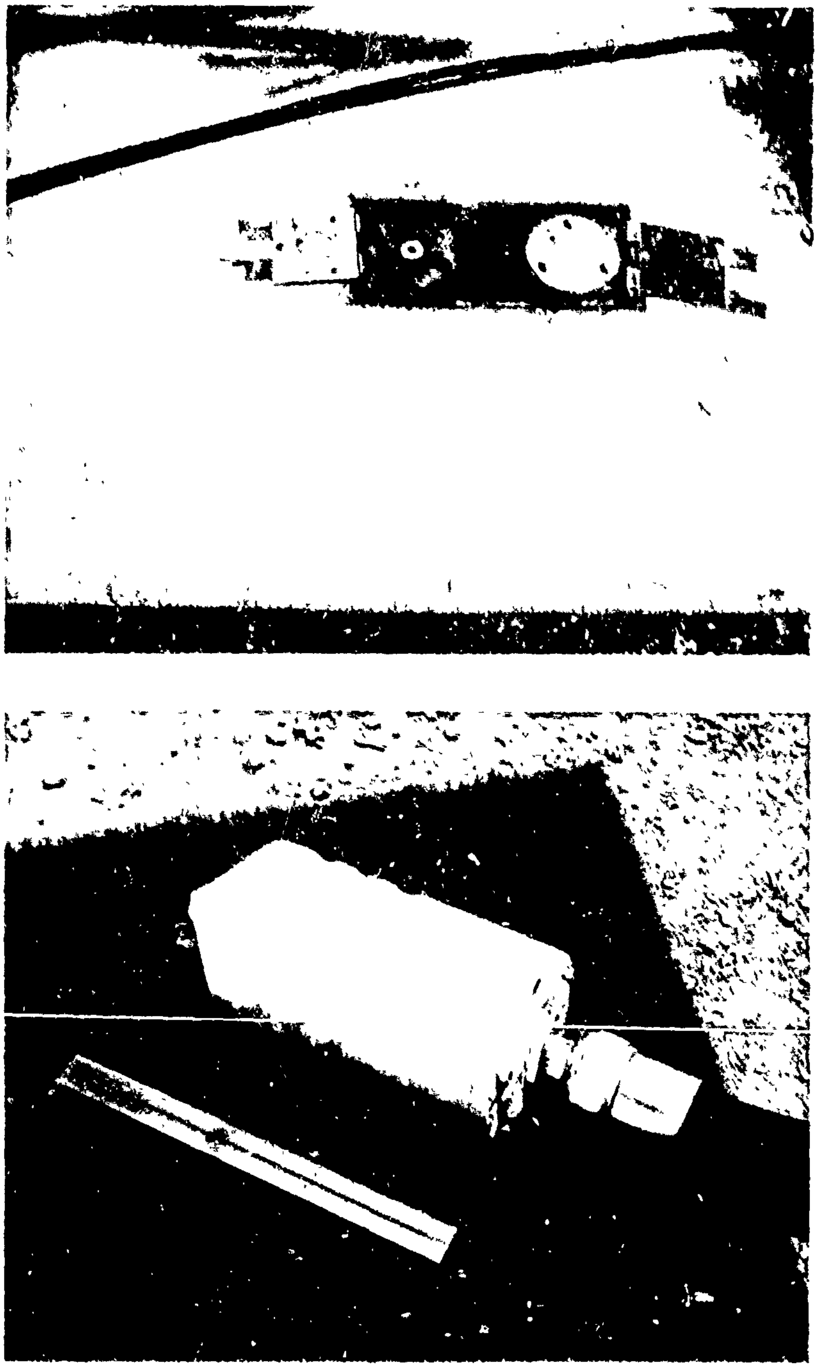
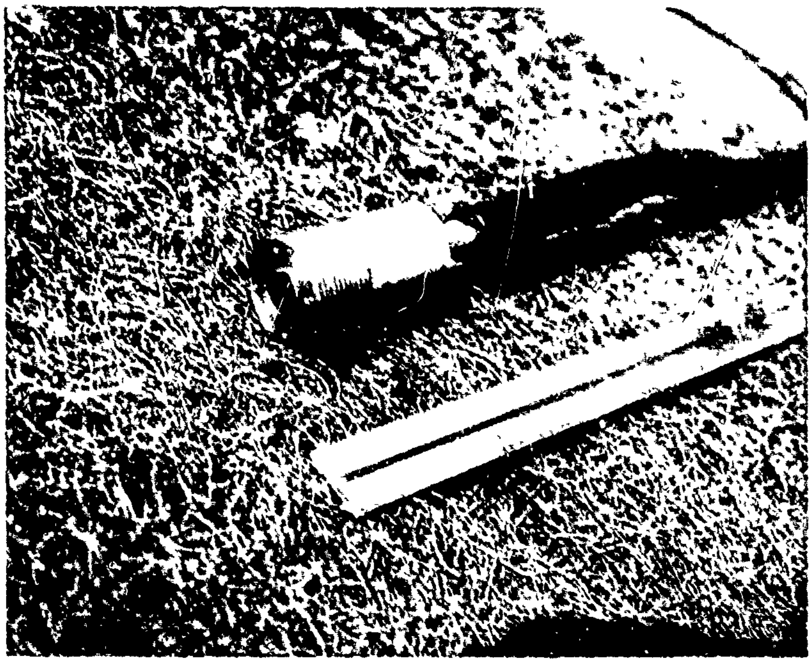


Figure 2-52. SLA Airblast Transducers (Top Photo), Acceleration Canister (Bottom Photo), Pre-DICE THROW II

Figure 2-53. SLA Gage Array, Pre-DICE THROW II



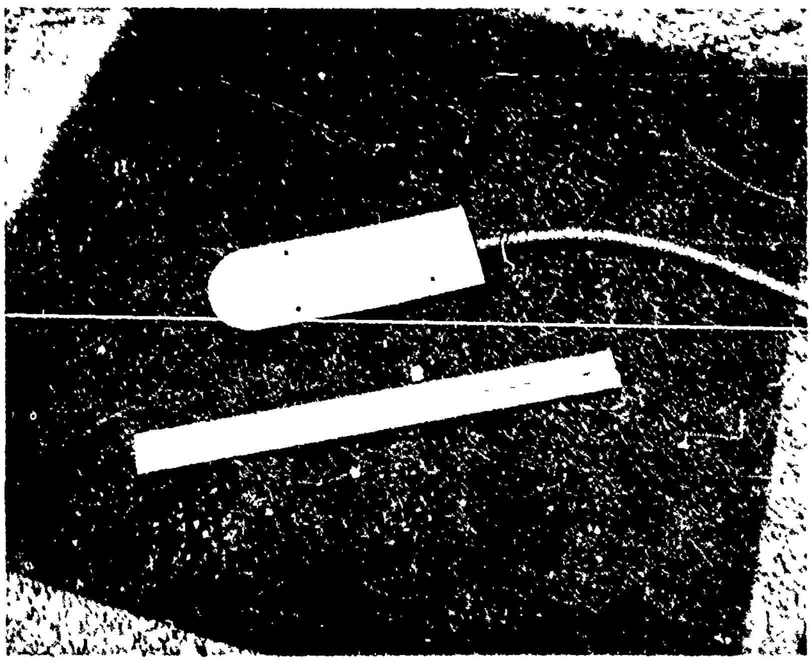


Figure 2-54. SLA Carbon Airblast Gage (Top Photo), Carbon Paddle Gage (Bottom Photo), Pre-DICE THROW II

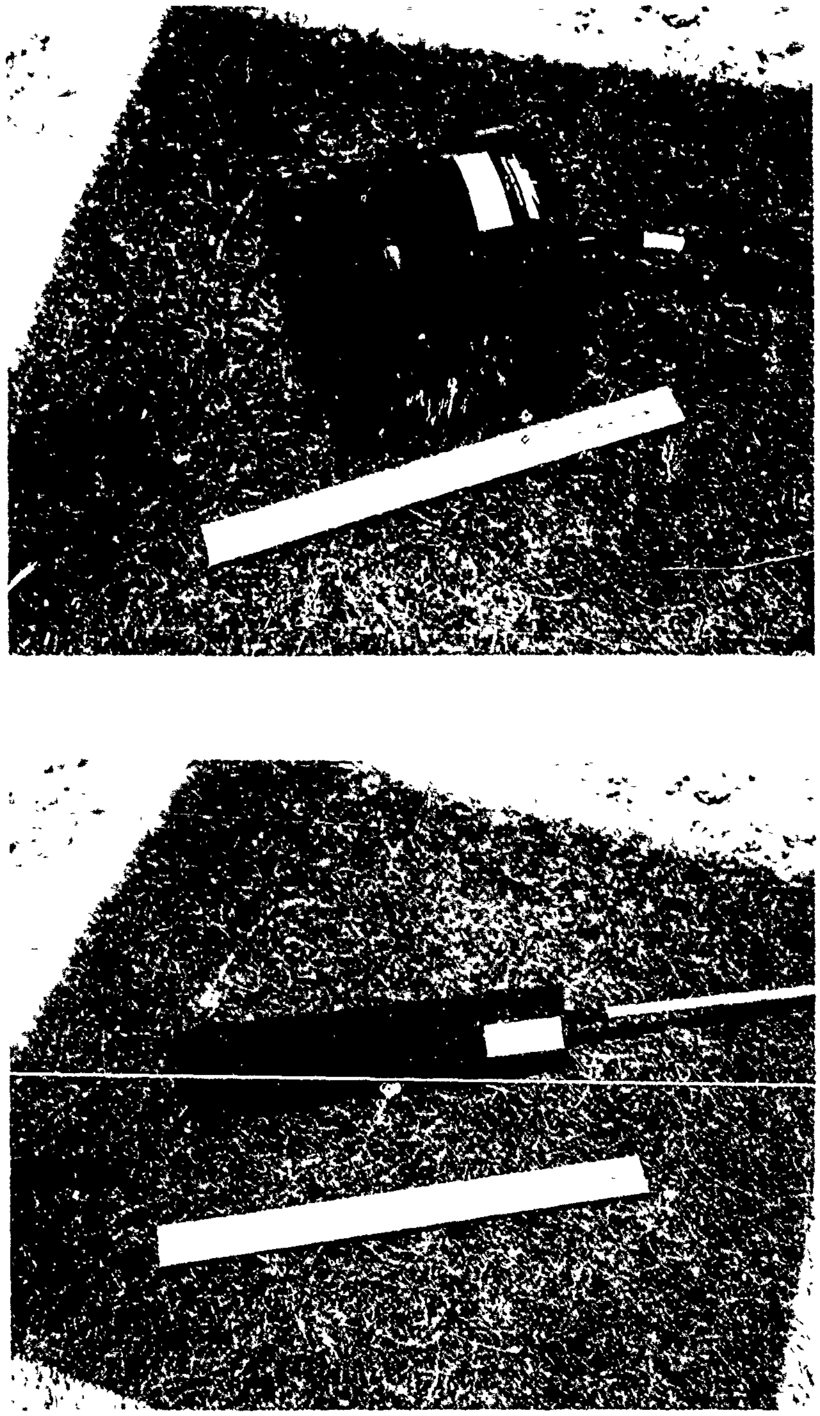


Figure 2-55. SLA Ytterbium Gages,
Pre-DICE THROW II

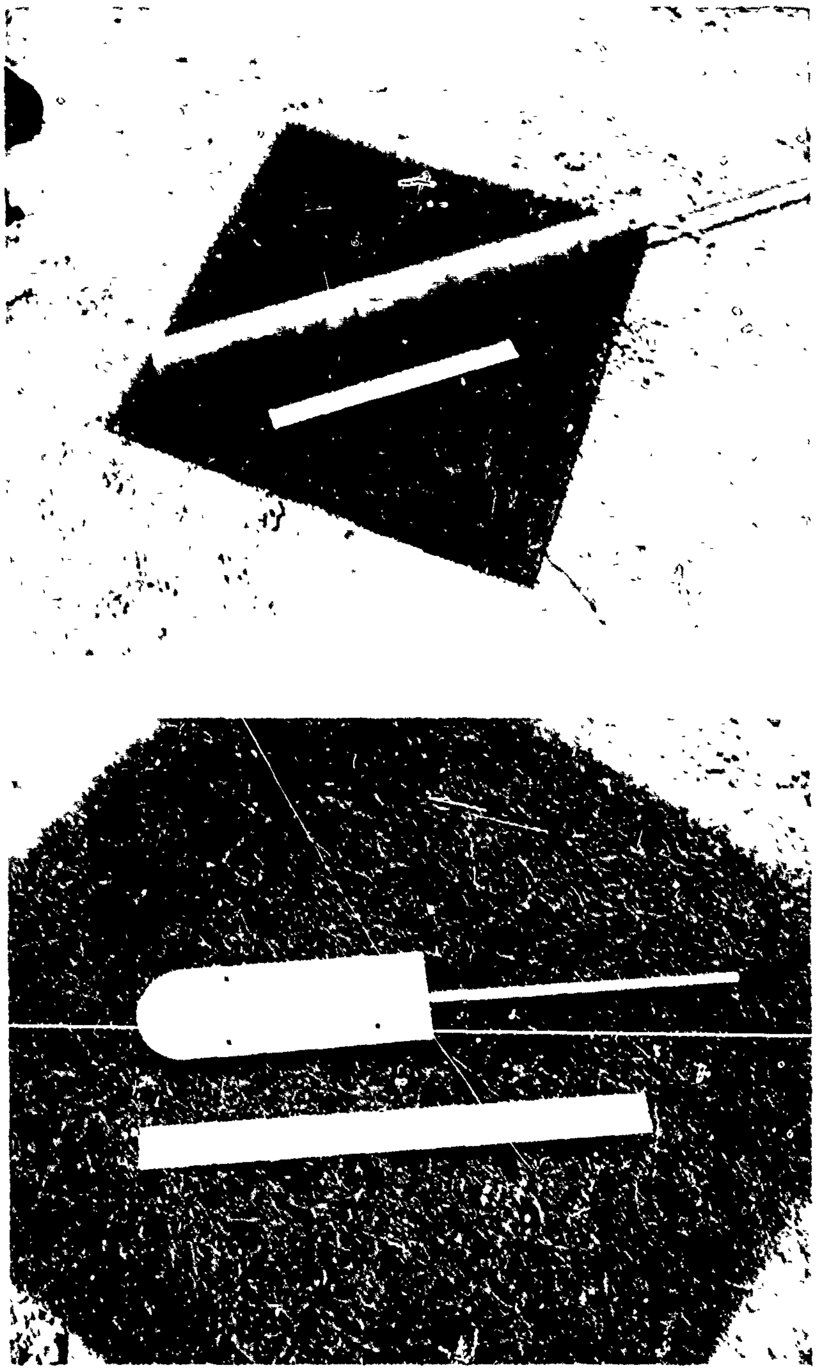


Figure 2-56. SLA Lithium Niobate Gages, Pre-DICE THROW II

and 1/3-kbar stress levels. The sensors included ytterbium gages in both paddle and cylinder configurations, carbon gages in the paddle configuration and lithium niobate gages in both bar and paddle forms. Lithium niobate gages, all with Z-cut crystals, were employed in several different orientations (refer to Table 2-14).

At the three closest stations the stress gages were oriented so as to point to the charge center, and the two farthest station gages were positioned horizontally in the anticipation of a vertical shock front.

(c) TITLE: Microbar Measurements (DNA Project No. 160-53)

PROJECT OFFICERS: Mr. B. Holt and Mr. J. Reed

OBJECTIVE: Provide microbar prediction and measurement services on both events for damage assessment studies.

EXPERIMENT DESCRIPTION: Measurement stations were placed in the closest inhabited communities which include Oscuro, Tularosa, Carrizozo and Alamogordo, New Mexico (refer to Figure 1-1). A tabulated listing of distances, arrival times, arrival velocities and pressure for the two events is contained in Tables 2-15 and 2-16. Radio-telemetry (TM) and microbarograph (MB) recording devices were co-located in Carrizozo.

13. Stanford Research Institute (SRI)/Kaman Sciences Corporation (KSC)

TITLE: Light-Detection and Ranging (LIDAR) Experiment (DNA Project Nos. 160-70, 71, POR #6911)

PROJECT OFFICERS: Dr. W. Viezee (SRI) and Mr. P. Jessen (Kaman Sciences)

OBJECTIVE: Evaluate the extent of laser performance degradation by the dust cloud generated by both events and provide diagnostic data on the history of the dust cloud.

EXPERIMENT DESCRIPTION: (Refer to Figures 2-57, 2-58, 2-59 and 2-60) The laser systems deployed in the field tests were available at SRI and were used at WSMR in mobile configurations.

Table 2-14. SLA Earth Stress Measurements, Pre-DICE THROW II-1

Gage	Configuration	Slant Distance (ft)	(m)
Li15-1	Z-cut bar	46.40	14.144
Li15-2	Z-cut bar	49.73	15.158
Li8-1	Z-cut bar	54.37	16.572
Li8-2	Z-cut bar	54.21	16.523
Li8-3	Z-cut paddle	54.24	16.533
Li8-4	Z-cut paddle, hydrostatic	54.12	16.497
Li3-1	Z-cut paddle	73.32	22.347
Li3-2	Z-cut paddle	73.40	22.373
Li3-3	Y-cut paddle, normal	73.44	22.386
Li3-4	Y-cut paddle, transverse	74.02	22.560
Li3-5	Z-cut paddle, hydro., normal	73.34	22.353
Li3-6	Z-cut paddle, hydro., transv.	73.53	22.413
Li1-1	Z-cut paddle, hydrostatic	74.04	22.568
Li1-2	Z-cut paddle, hydrostatic	96.89	29.532
Li1/3-1	Z-cut paddle, hydrostatic	133.88	40.806
Li1/3-2	Z-cut paddle, hydrostatic	133.90	40.812
Yb15-1	Cylinder	46.43	14.151
Yb15-2	Paddle	46.42	14.148
Yb 8-1	Cylinder	54.02	16.464
Yb 8-2	Paddle	54.24	16.533

Table 2-15 Pre-DICE THROW II, Event 1, Rawinsonde Upper Air Reports

Rawinsonde Upper Air Reports, SLA Data (Temperatures: °C; Winds: °Azimuth, Knots)							
	DAY:			8/12/75			
Temperature/Wind Surface MSL	TIME:	0830 MDT		0955 MDT SHOT		1107 MDT (SHOT)*	
(ft)	(m)	T	W	T	W	T	W
4400	1341.12	+22.1	180/6	+24.8	180/8	+28.4	200/8
5000	1524.[illegible]	20.3	180/7	22.9	175/8	24.7	185/15
6000	1828.80	18.5	185/8	19.3	185/10	22.0	185/14
7000	2133.60	16.6	195/8	17.1	185/12	19.7	185/13
8000	2438.40	14.6	220/8	15.1	190/9	17.1	210/9
9000	2743.20	12.6	250/8	13.1	220/7	15.0	250/6
10000	3048.00	10.8	270/11	11.0	235/10	12.2	270/7
12000	3657.60	6.6	280/8	6.2	305/6	7.7	320/6
14000	4267.20	2.1	075/5	1.6	135/2	2.8	190/3
16000	4876.80	-2.9	080/12	-2.8	145/12	-2.9	130/9
18000	5486.40	-5.0	200/4	-6.2	310/8	-6.6	080/6
20000	6096.00	-9.7	140/4	-10.1	070/5	-10.0	025/6

*Surface Pressure: 867.5 mbar

Table 2-16. Pre-DICE THROW II, Event 2, Rawinsonde Upper Air Reports

Rawinsonde Upper Air Reports, SLA Data (Temperatures: °C; Winds: °Azimuth, Knots)							
Temperature/Wind Surface MSL	DAY: TIME:	0940 MDT		9/22/75 1100 MDT		1200 MDT (Shot)*	
(ft)	(m)	T	W	T	W	T	W
4400	1341.12	+14.1	160/3	+16.4	CALM	+19.0	030/9
5000	1524.00	11.1	045/2	14.5	035/8	17.2	030/13
6000	1828.80	9.3	030/11	11.5	040/14	14.2	030/12
7000	2133.60	7.3	025/18	9.9	045/17	11.1	025/9
8000	2438.40	5.2	040/23	7.3	045/17	7.9	030/7
9000	2743.20	3.3	045/23	5.0	055/17	4.5	030/8
10000	3048.00	1.3	080/20	2.8	055/16	3.1	055/9
12000	3657.60	-1.0	050/17	-0.8	055/17	0.2	055/10
14000	4267.20	-1.7	025/11	-1.4	045/16	1.0	015/11
16000	4876.80	-5.7	015/10	-5.3	030/14	-3.9	010/15
18000	5486.40	-9.9	355/17	-9.8	355/14	-8.9	350/15
20000	6096.00	-13.8	345/18	-14.1	335/14	-13.8	340/15

*Surface Pressure: 876.5 mb

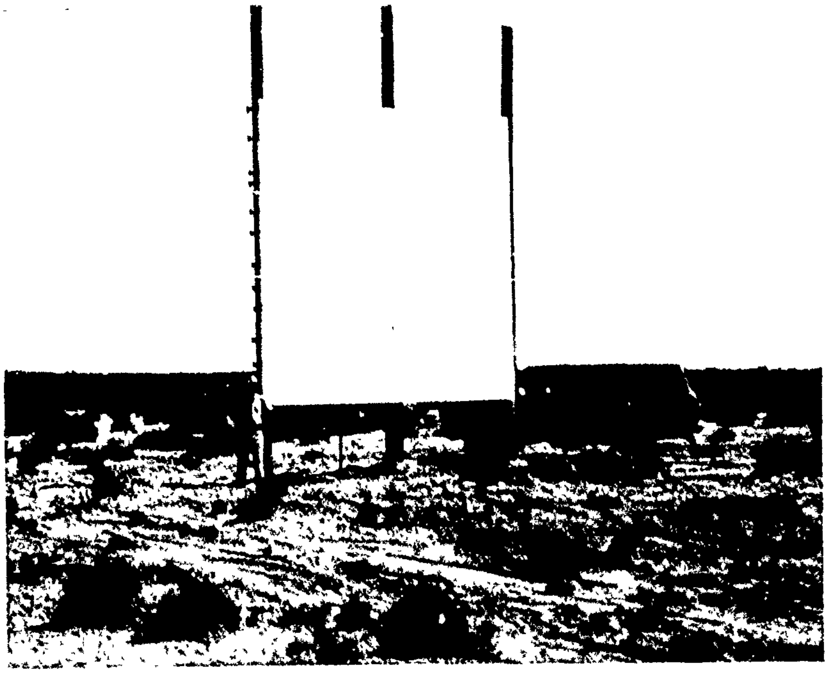
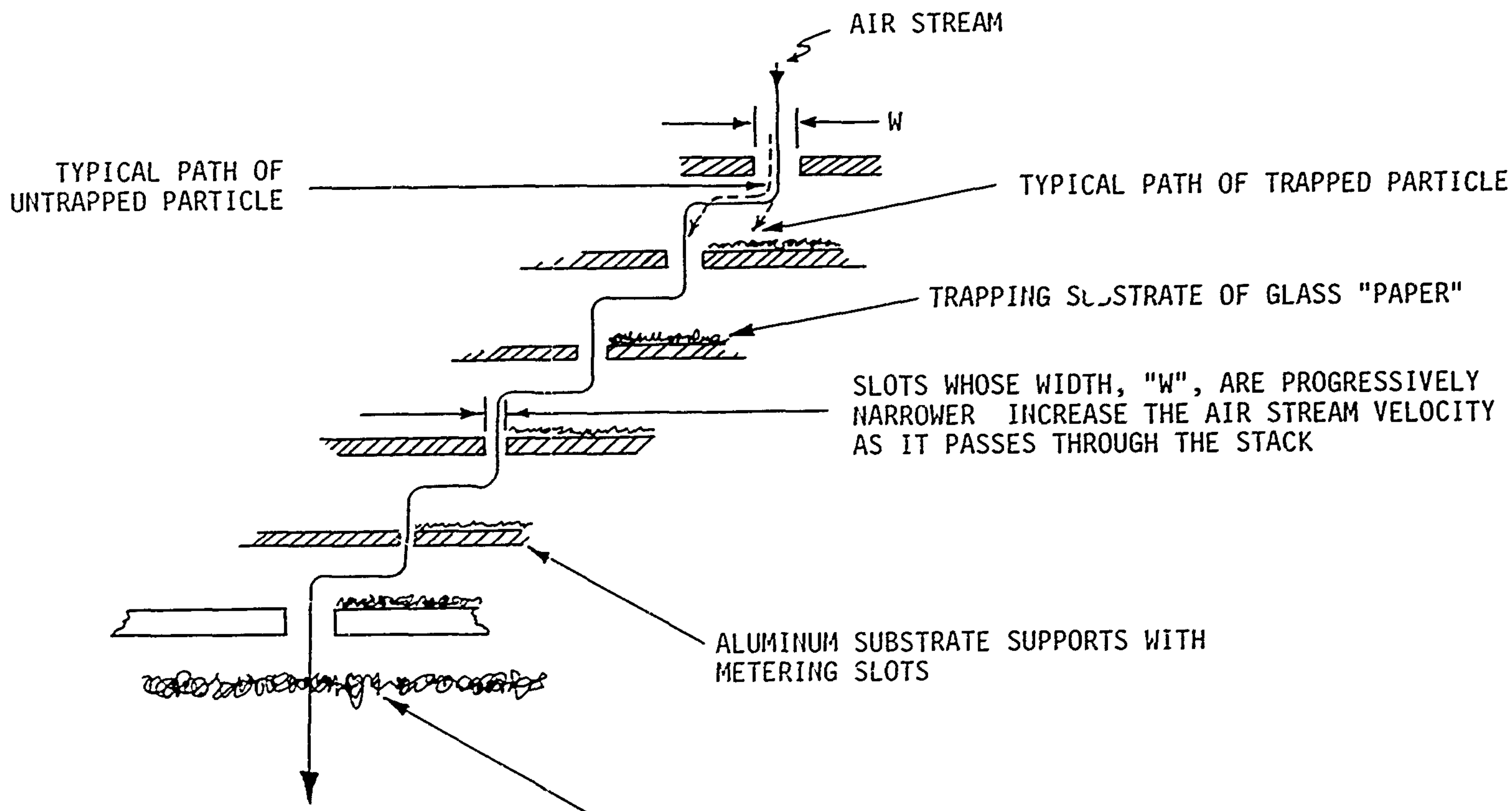


Figure 2-57. SRI LIDAR Experiment, Laser System (Top Photo), Target (Bottom Photo), Pre-DICE THROW II



Reference="Series 230 high volume impactors", Sierra Instruments, Inc.

Figure 2-58. Kaman Sciences Aerodynamic Sorter Concept, Pre-DICE THROW II

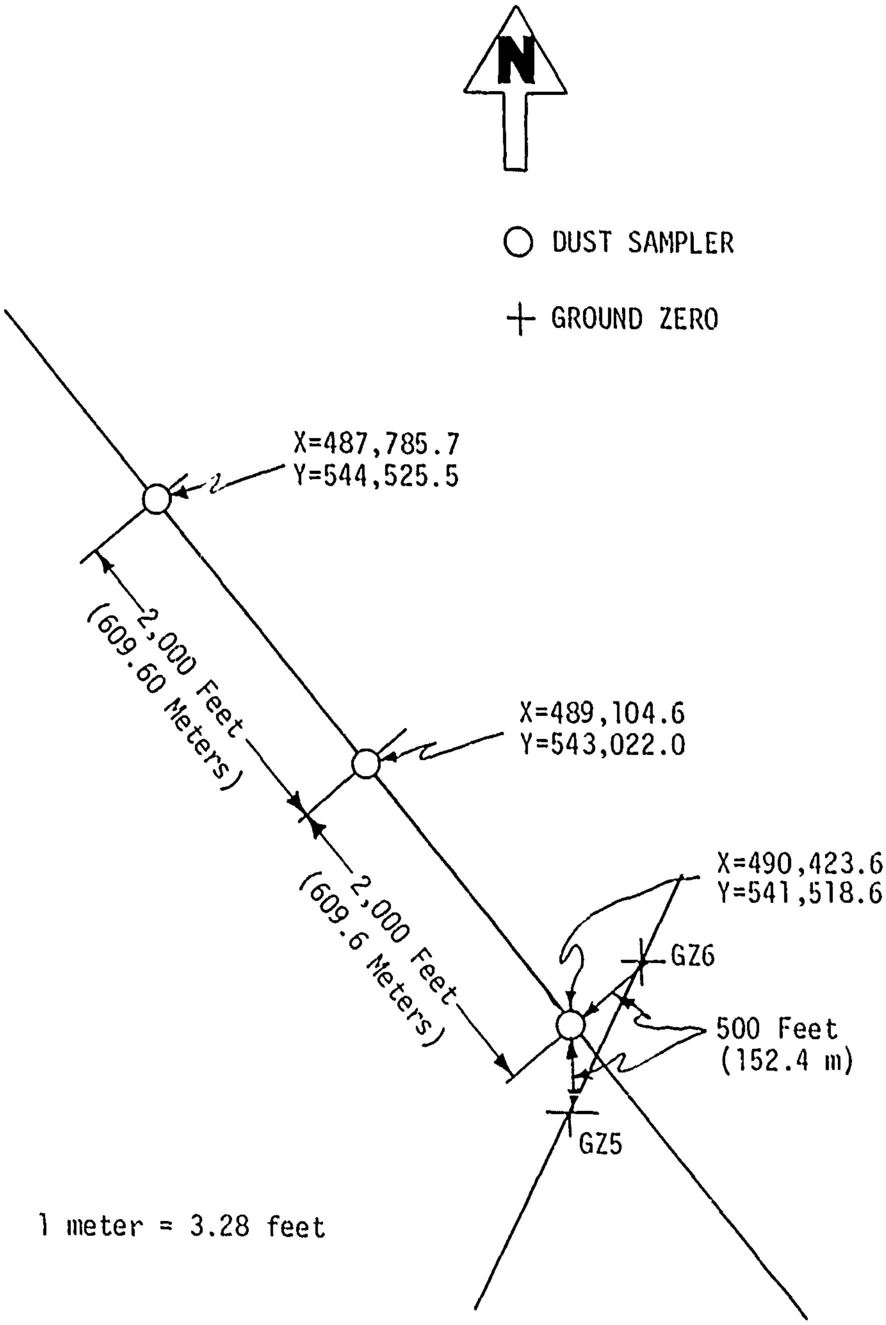


Figure 2-59. Kaman Sciences Layout for Dust Samplers, Pre-DICE THROW II

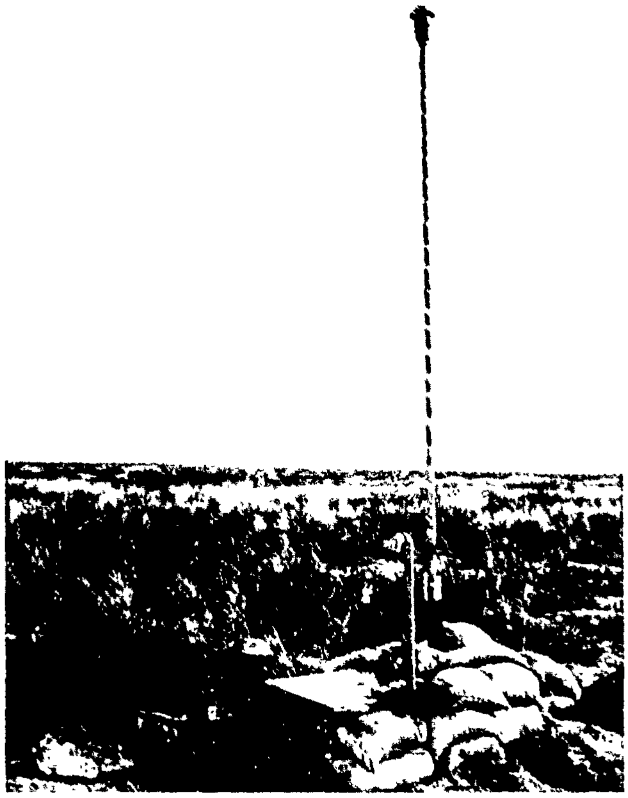


Figure 2-60. Photograph of Kaman Science Dust Sampler, Pre-DICE THROW II

(a) Pre-DICE THROW II, Event 1

This experiment included a pulsed neodymium LIDAR (1060-nm wavelength) pointed at a stationary passive target along a fixed line-of-sight offset about 400 ft (121.92 m) from detonation (GZ). The LIDAR system with its power supply and data recording equipment housed in a closed van, was located 5430 ft (1655.06 m) northwest of GZ with the solid white reflecting target (~0.98 reflectivity) placed at a distance of 4000 ft (1219.20 m) southeast of GZ. The target center was 12 ft (3.66 m) above ground.

The mode of operation involved illumination of the 16x16-ft (4.88x4.88-m) solid target every 10 seconds with 1.5 joules laser energy in a 30-nanosecond pulse (50 megawatts output power), and measuring the laser radiation reflected back toward the LIDAR receiver. By calibrating the reflection characteristics of the target under natural (pre-detonation) atmospheric background conditions, the history of the target-reflected laser signal received during the HE test can be related to the history of atmospheric laser transmission over the 9430-ft (2874.26-m) LIDAR-to-target distance. Also, by monitoring the backscatter from dust along the line of sight, diagnostic data related to the history of the HE dust cloud is provided. The LIDAR/target experiment was conducted during the Pre-DICE THROW II 100-ton (90.7-metric-ton) TNT and 120-ton (108.9-metric-ton) ANFO events.

(b) Pre-DICE THROW II, Event 2

In a second experiment, a pulsed ruby LIDAR (694.3-nm wavelength) with the capability to automatically scan in azimuth and elevation, was used to observe atmospheric back-scatter of clutter from the dust cloud. With a pulse-repetition rate of one 30-nanosecond pulse per second, this narrow-beam (0.5-milliradian beam divergence), high-power (50 megawatts) system mapped the configuration of the dust cloud from a location 6248 ft (1904.39 m) southwest of GZ. The ruby LIDAR monitored the dust cloud while scanning from 0-degree elevation (laser beam 45 ft (13.72 m) above GZ 6). Azimuth scans were made from 0 degree (laser beam pointed at GZ 6) to 10 degrees right azimuth relative to GZ 6 at constant elevation angles between 0 and 15 degrees.

Aerodynamic sorters were used by Kaman Sciences Corporation to collect the dust samples. Figure 2-58 shows this concept. Each stage eliminates particles of progressively greater aerodynamic drag-to-weight ratio (1/β). These stages are followed by a final filter which traps all remaining particles, down to about 0.1μM diameter. For particles having roughly equal dimensions in all directions, the larger particles are trapped in stage 1 and the smaller in stage 5. The sorters were located as shown in Figure 2-59. These points were chosen to be a few feet from the 1060-mm LIDAR beam path.

The sampler inlets were opened and closed simultaneously. On Pre-DICE THROW I the sample collection was started at 5.0 minutes after detonation and terminated 2.5 minutes later. On the second event, start time was 1.5 minutes after detonation and termination was 45 seconds later.

14. Stanford Research Institute (SRI)

TITLE: Crater Stress Measurements (DNA Project No. 160-67, POR #6908)

PROJECT OFFICER: Mr. C. Smith

OBJECTIVE: Detail the ground-shock environment in the near-source region and determine what charge-characteristic differences might be exhibited from TNT and ANFO detonations in an assumed similar geology.

EXPERIMENT DESCRIPTION· (Refer to Figures 2-61 and 2-62) Six ytterbium stress gages were fielded on each of the Pre-DICE THROW II Events.

In addition to the stress gages, a PZT crystal was placed in a hole on the line between ground zero (GZ) and the first gage, and just a few feet ahead of the first gage. This crystal was to act as an auxiliary scope trigger for critically timed data.

The stress-gage locations relative to the ground surface and the explosive are shown in Figure 2-62 for each event. For the 100-Ton (90.7-Metric-Ton) TNT Event, SRI gages were located along an azimuth of 257 degrees. The gages were located on the 271-degree azimuth for the 120-Ton (108.9-Metric-Ton) ANFO Event. The geology, as specified by WES, at the various gage locations is also shown in Figure 2-62. Oscilloscope records of gage output signals were digitized to obtain accurate stress-time history data.

15. Systems, Science and Software (SSS)

TITLE: Close-In Ground Shock and Airblast Measurements (DNA Project No. 160-61, POR #6909)

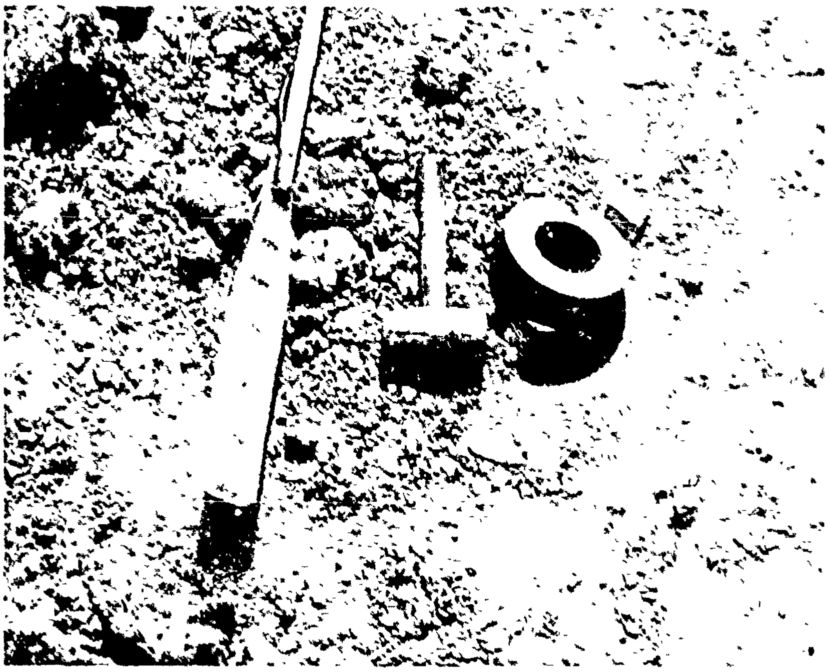


Figure 2-61. SRI Stress Gages, Pre-DICE THROW, Events 1 and 2

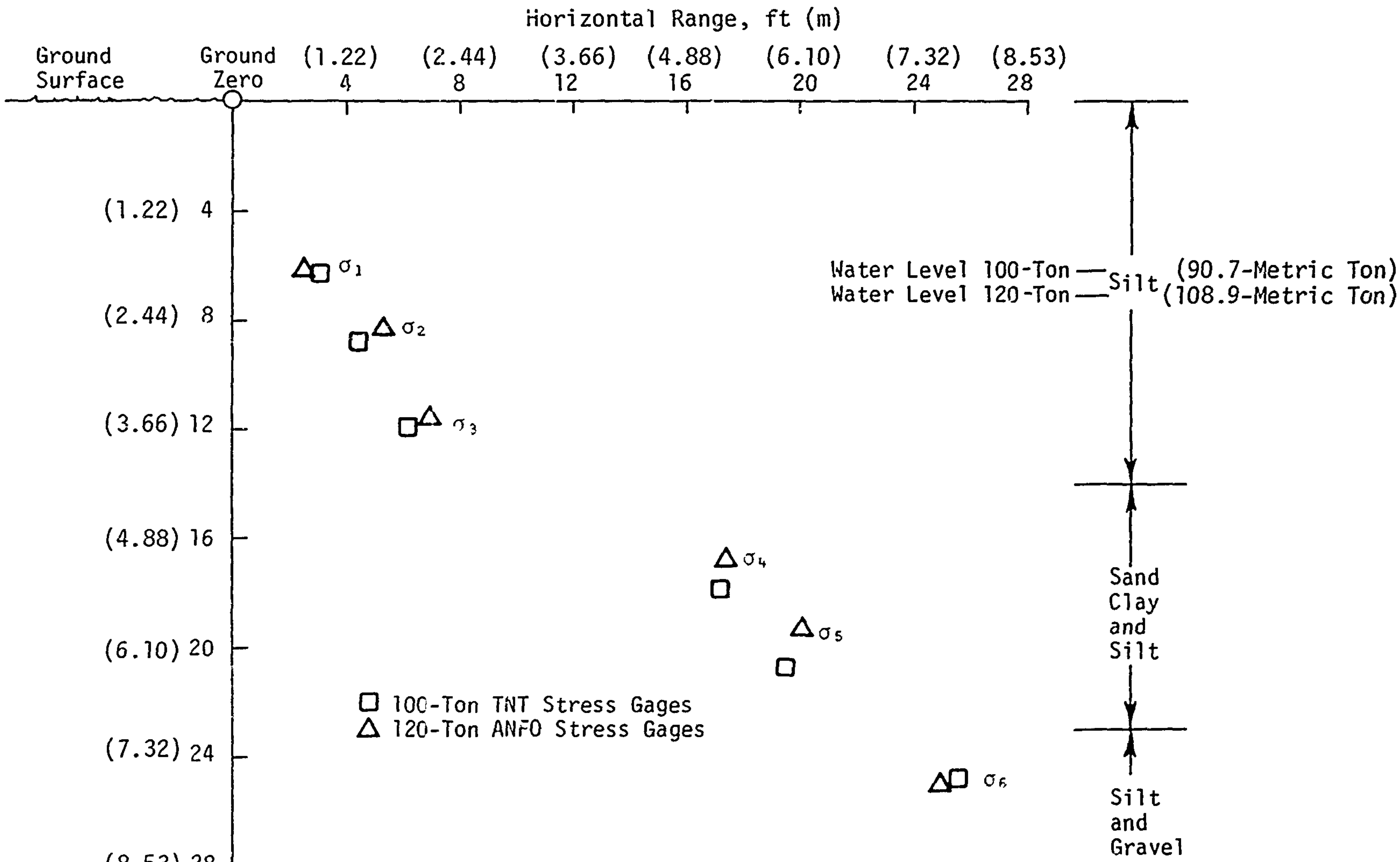


Figure 2-62. SRI Gage Locations Relative to Explosive and Ground Surface, Pre-DICE THROW II, Events 1 and 2

PROJECT OFFICER: Dr. E. Gaffney

OBJECTIVE: Make airblast and ground-shock measurements and test the use of an SSS-designed hardened-quartz gage for measurement of airblast.

EXPERIMENT DESCRIPTION: Six airblast gages and six ground-stress gages were installed on each event. Gage locations were as shown in Figure 2-63 for the airblast measurements, and in Figures 2-64 and 2-65 for the ground-stress measurements. (The gage number-scheme is as follows: the letter S or A refers to ground shock or airblast, respectively; the numbers 1 - 6 indicate gage location; and the Roman numerals I or II indicate the TNT event or the ANFO event, respectively. Gages S1-I and S1-II are in similar positions, etc.) Gages S1 and S2 were placed at the bottom of pits 4-1/2 ft (1.37 m) deep, back-filled with soil and tamped with a pneumatic foot. These two gages were oriented to measure a horizontal stress radial from GZ. Gages S3, S4, S5 and S6 were emplaced in 45-degree slant holes filled with E-2(D) grout, a soil-matching grout designed for a previous test by the Soils and Pavements Laboratory of the U. S. Army Waterways Experiment Station (WES). These gages were oriented to measure stress radially downward from GZ at 45 degrees.

The airblast gages, A1-I through A6-I, were emplaced in pools of RTV-602, a low-loss, transparent silicone rubber. In the ANFO event, the gage was closer to the surface of the RTV, and the pit did not extend more than a few centimeters onto the preamplifier housing. This modification was undertaken to eliminate high-frequency noise seen in results from the TNT event. Low temperatures prior to the ANFO event apparently prevented the RTV from curing in some of the gages.

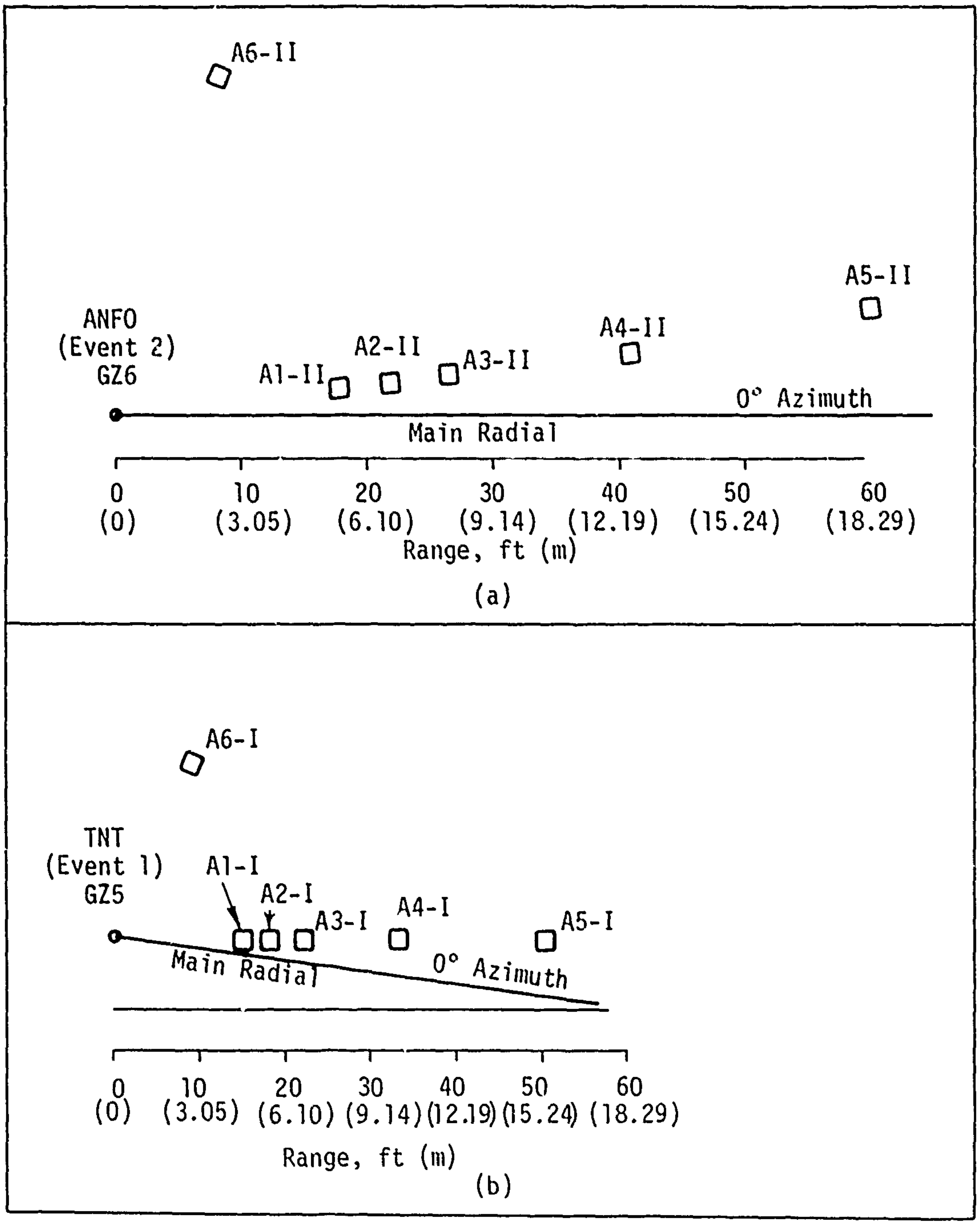


Figure 2-63. SSS Airblast Gage Locations, Pre-DICE THROW II, Events 1 and 2, (a) ANFO, (b) TNT

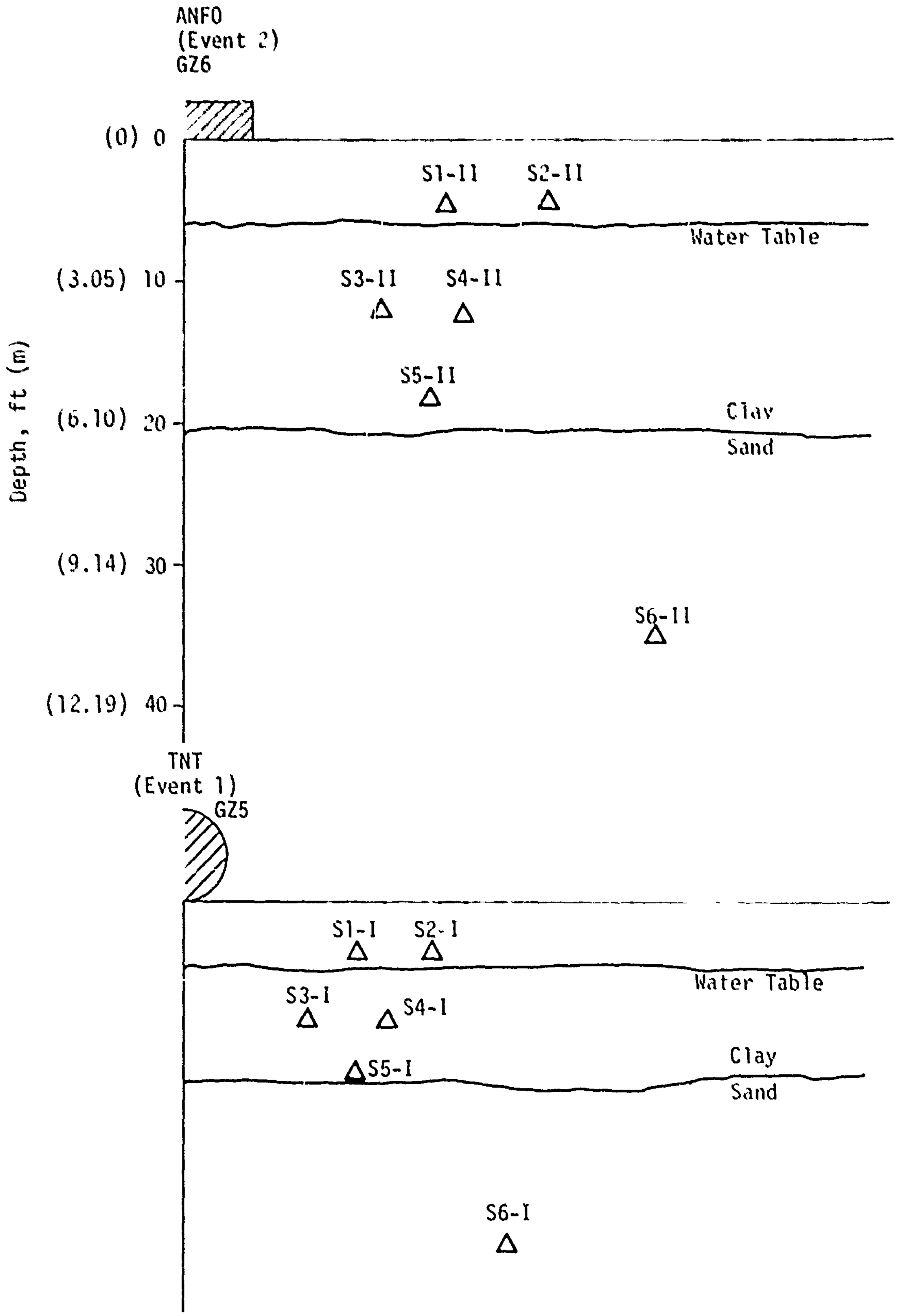


Figure 2-64. SSS Stress Gage Locations, Pre-DICE THROW II, Events 1 and 2

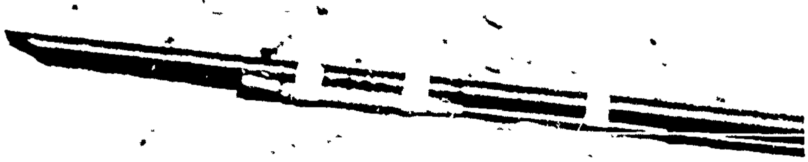


Figure 2-65. SSS Stress Gages, Pre-DICE THROW II

16. Denver Research Institute (DRI) (Refer to POR 6917, Technical Photography from Pre-DICE THROW I and II, March, 1976)

TITLE: Technical Photography

PROJECT OFFICER: Mr. J. Wisotski

OBJECTIVES: Record and analyze the early-, intermediate-, and late-times phenomena from the Pre-DICE THROW II series so as to determine the behavior of ammonium nitrate/fuel oil (ANFO) detonations as compared to equivalent trinitrotoluene (TNT) detonations.

EXPERIMENT DESCRIPTION: (Refer to Figure 2-66) The DRI instrumentation for Pre-DICE THROW II, Events 1 and 2, consisted of 17 high-speed cameras ranging in framing rates from 20 to 33,000 frames per second and two photometric devices located at the camera station situated approximately 4500 ft (1371.6 m) from each of the GZs. The photometric devices consisted of modified and unmodified solarcells. The photometric traces were recorded on a dual-beam oscilloscope. All cameras except the two Dynafax cameras had timing light systems. The parameters investigated were: detonation velocity, peak amplitudes and times of total light radiation, when and where the main shockwave passed the surface-surge fireball, anomalies, shockwave time-of-arrival, fireball dimensions, angles of upper and lower ejecta spires and cloud dimensions. Refer to Tables 2-17 and 2-18 for camera details.

17. U. S. Army Engineer Waterways Experiment Station (WES)

(a) TITLE: Ground Motion Measurements (DNA Project No. 160-59, POR #6910)

PROJECT OFFICERS: Mr. D. Day and Mr. D. Murrel

OBJECTIVES: Assess the ground-shock environment produced by the two Pre-DICE THROW II Events, and correlate the results between the 100-Ton (90.7-Metric-Ton) TNT Event (Event 1) and the 120-Ton (108.9-Metric-Ton) ANFO Event (Event 2) and compare the results from both events with those from similar tests in different media.

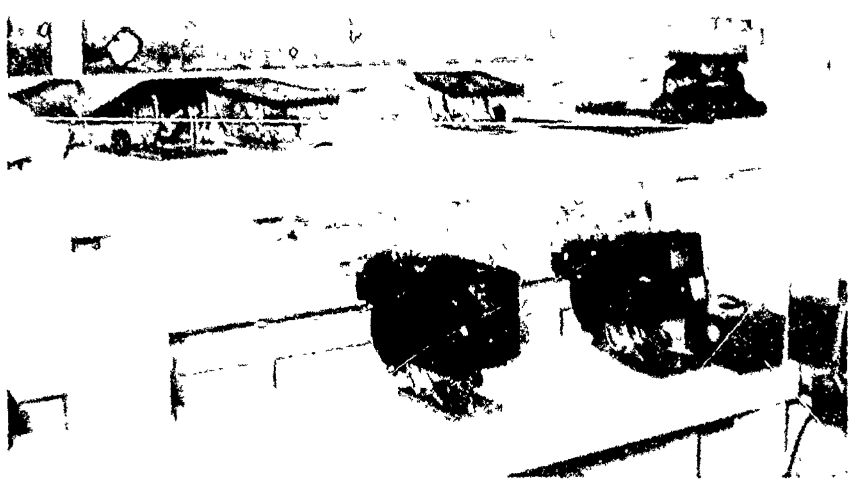


Figure 2-66. DRI Technical Photography Camera Stations, Manned Station (Top Photo), Remote Station (Bottom Photo), Pre-DICE THROW II

Table 2-17. DRI Camera Details, Pre-DICE THROW II, Event 1

Camera Type	Location	Lens (mm)	Framing Rate (frames/sec)	View	Field of View, ft (m)
DB Milliken	Main	17	201	Chg Centered	2780 x 1980 (847.34 x 603.50)
Locam	Main	27.5	495	Chg Centered	1720 x 1220 (524.26 x 371.86)
Hycam	Main	75	3,460	Chg Centered	620 x 440 (188.98 x 134.11)
Hycam (1/4)	Main	100	33,100	Chg Centered	460 x 330 (140.21 x 100.58)
Fastax	Main	50	4,680	Lt of Chg	920 x 660 (280.42 x 201.17)
Fastax	Main	100	4,760	Lt of Chg	460 x 330 (140.21 x 100.58)
Fastax	Main	50	4,120	Rt of Chg	920 x 660 (280.42 x 201.17)
Fastax	Main	100	4,680	Rt of Chg	460 x 330 (140.21 x 100.58)

NOTE: Camera Distance = 4,537 ft (1,382.88 m)

Table 2-18. DRI Camera Details, Pre-DICE THROW II, Event 2

Camera Type	Location	Lens (mm)	Framing Rate (frames/sec)	View	Field of View, ft (m)
DB Milliken	Main	17	198	Chg Cent	2740 x 1950 (835.15 x 594.36)
Locam	Main	27.5	488	Chg Cent	1690 x 1200 (515.11 x 365.76)
Hycam (1/4)	Main	100	30,990	Chg Cent	450 x 325 (137.16 x 99.06)
Hycam	Main	75	7,240	Chg Cent	610 x 435 (185.93 x 132.59)
Nova	Main	150	5,400	Lt of Chg	305 x 720 (92.96 x 219.46)
Fastax	Main	100	4,800	Lt of Chg	450 x 325 (137.16 x 99.06)
Fastax	Main	50	4,630	Lt of Chg	905 x 650 (275.84 x 198.12)
Fastax	Main	100	4,480	Rt of Chg	450 x 325 (137.16 x 99.06)
Fastax	Main	50	4,520	Rt of Chg	905 x 650 (275.84 x 198.12)

NOTE: Camera Distance = 4,471 ft (1,362.76 m)

EXPERIMENT DESCRIPTION: Event 1 was instrumented with 202 channels of stress, acceleration, and particle-velocity gages extending over a range of 40 to 600 ft (12.19 to 182.88 m) and a depth of 1.5 to 60 ft (0.46 to 18.29 m). Event 2 was instrumented to a lesser degree, with 112 channels of similar gages extending over a range of 40 to 400 ft (12.19 to 121.92 m) and a depth of 1.5 to 40 ft (0.46 to 12.19 m). For both events, instrumentation was installed into the region of outrunning motion. The majority of the measurements were concentrated in the upper 20 ft (6.10 m) of the soil profile. Only selected ranges were instrumented to the greater depths.

Three radials were instrumented for each event: a primary radial, which contained about 2/3 of the total instrumentation, and two auxiliary radials, at 120 degrees and 240 degrees referenced to the primary radial. In addition, on Event 1 the 110-ft (33.53-m) ground range was instrumented at two depths on supplements 60-, 180- and 300-degree radials to examine test-bed azimuthal symmetry.

For Event 1, the 202 measurements included 108 velocity gages, 78 accelerometers and 16 stress gages. For Event 2, there were 72 velocity gages, 32 accelerometers and 8 stress gages. Refer to Figure 2-67 through 2-70 for gage layouts and profiles. Figures 2-71 and 2-72 depict the gages and their installation.

(b) TITLE: Permanent Displacement and Crater Measurements (DNA Project No. 160-60, POR #6912)

PROJECT OFFICER: Mr. J. Meyer

OBJECTIVES: Determine the basic dimensions of the apparent crater: radius, depth, and volume; measure the permanent surface displacements; and obtain estimates of true crater dimensions through limited excavation.

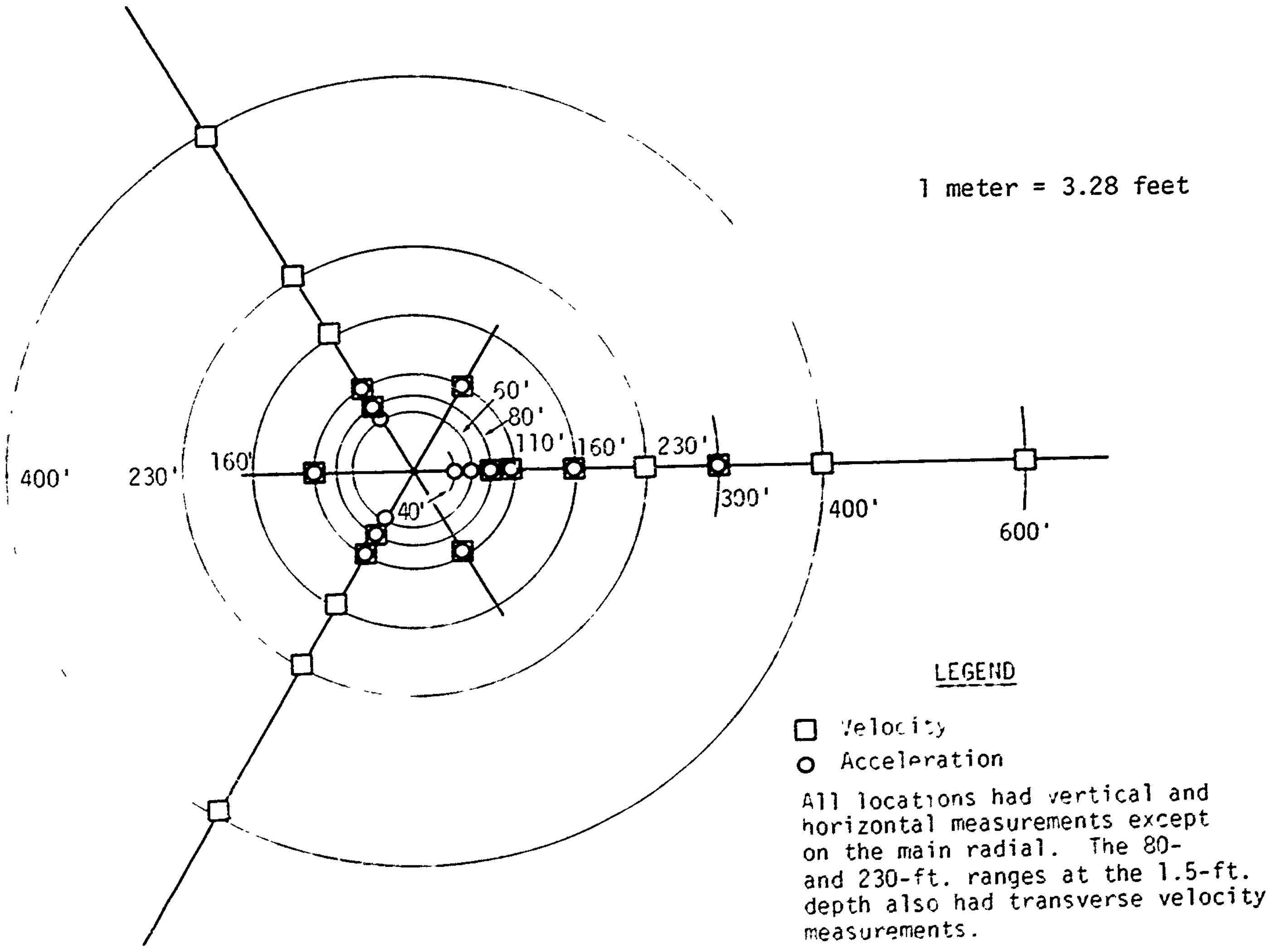


Figure 2-67. Pre-DICE THROW II, Event 1 Gage Placement Pattern Surrounding Ground Zero, WES Ground Motion

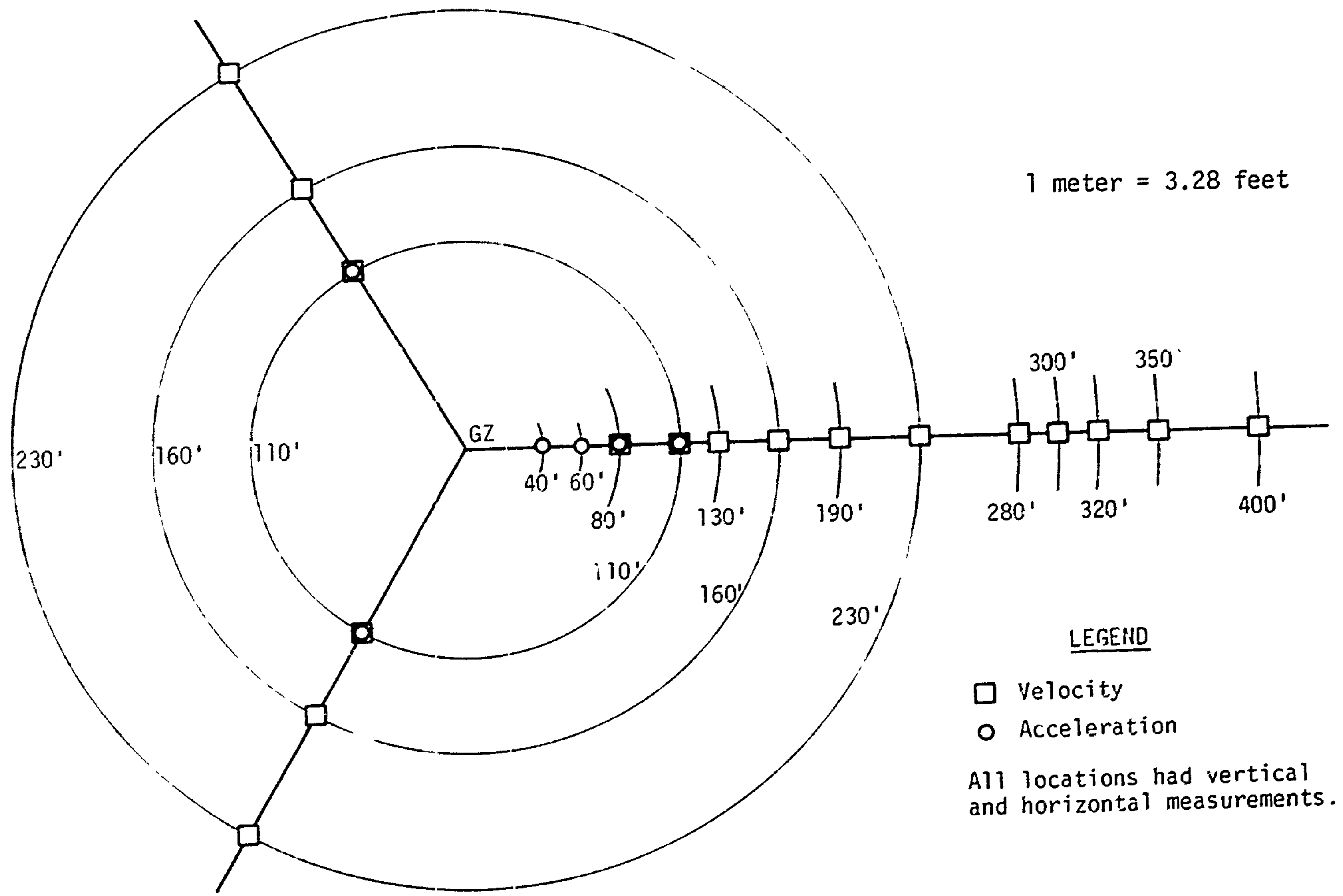


Figure 2-68. Pre-DICE THROW II, Event 2 Gage Placement Pattern Surrounding Ground Zero, WES Ground Motion

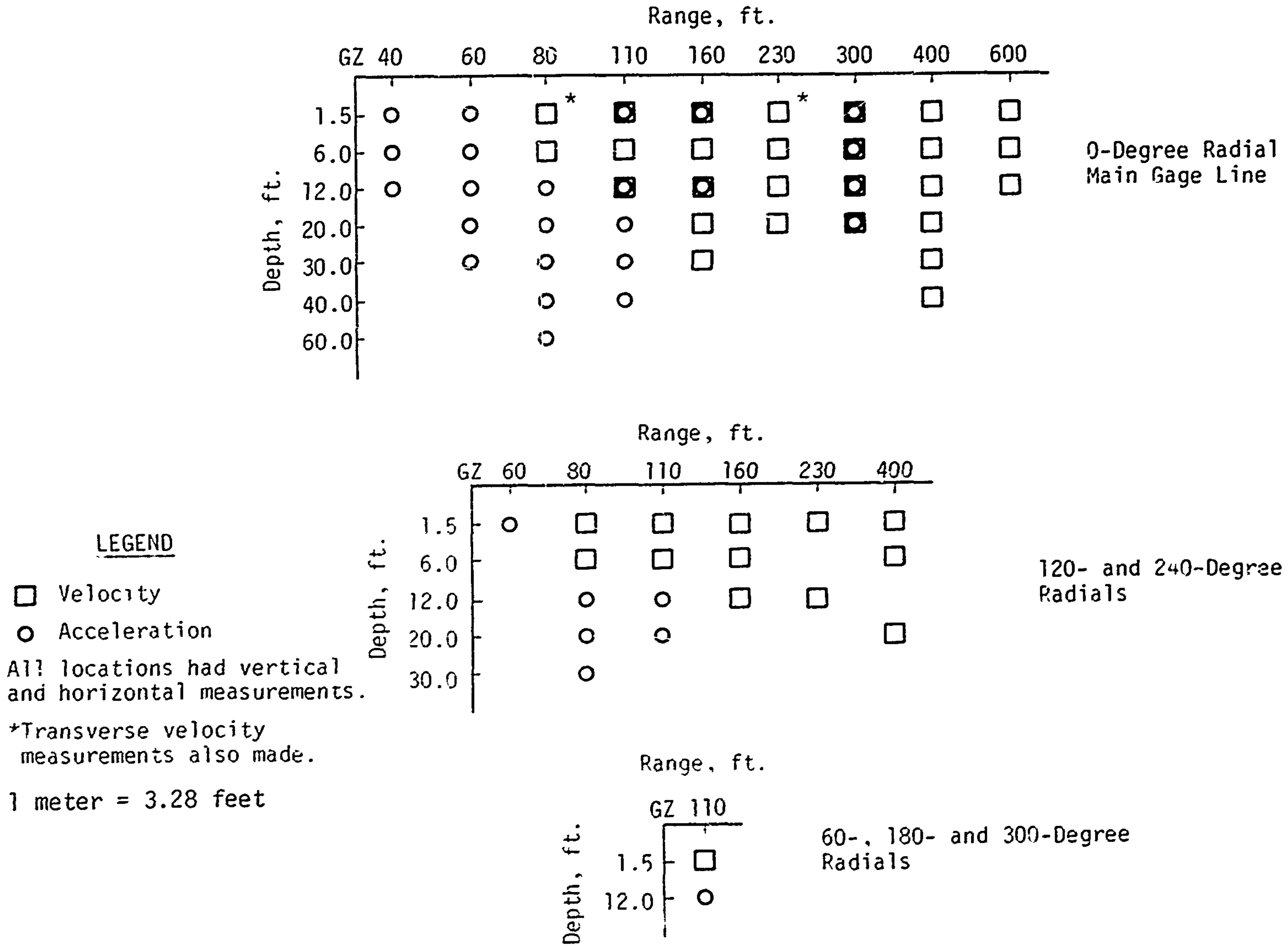


Figure 2-69. Pre-DICE THROW II, Event 1, Accelerometer and Velocity Gage Profiles, WES

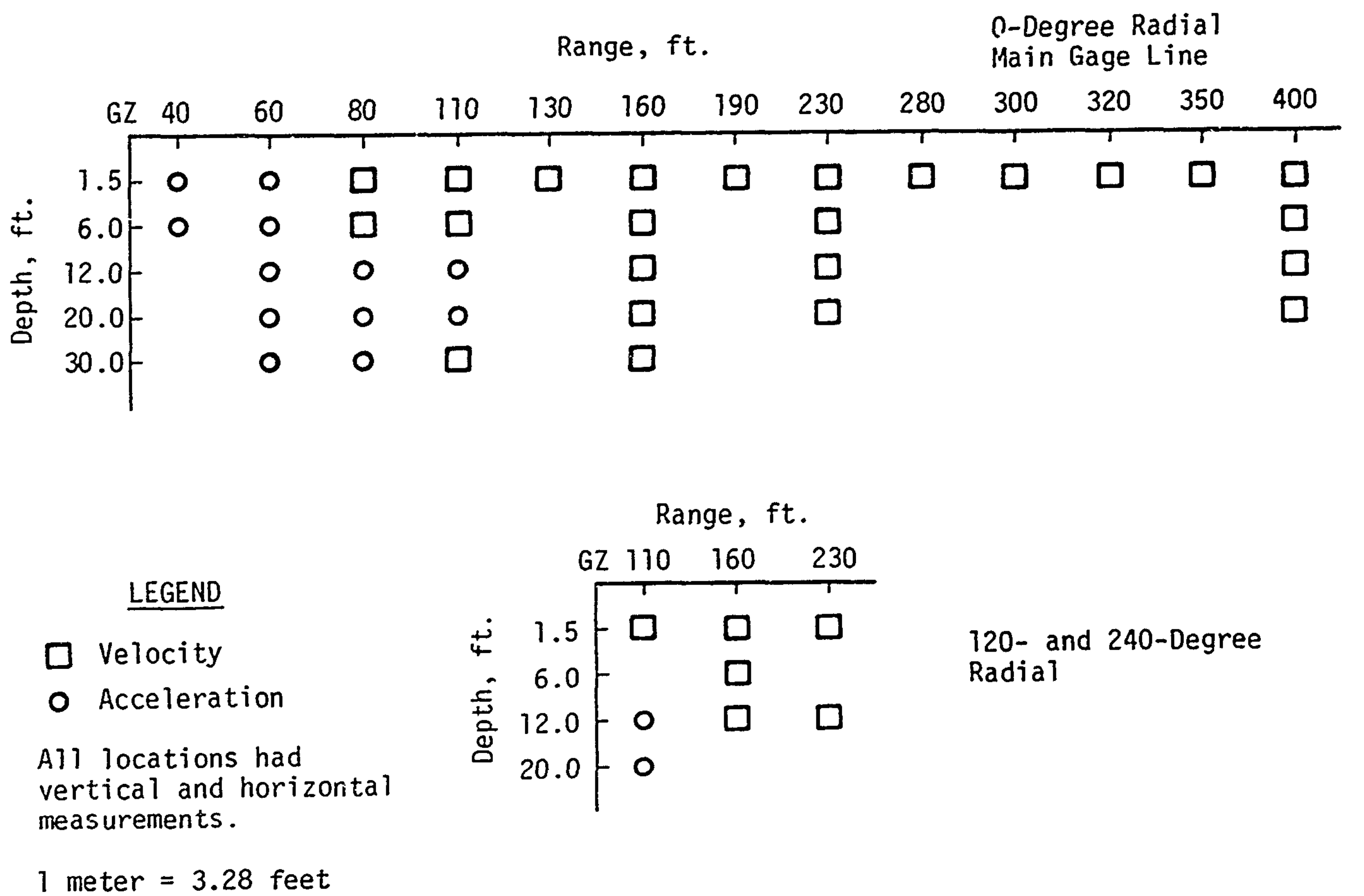


Figure 2-70. Pre-DICE THROW II, Event 2 Acceleration and Velocity Gage Profiles, WES

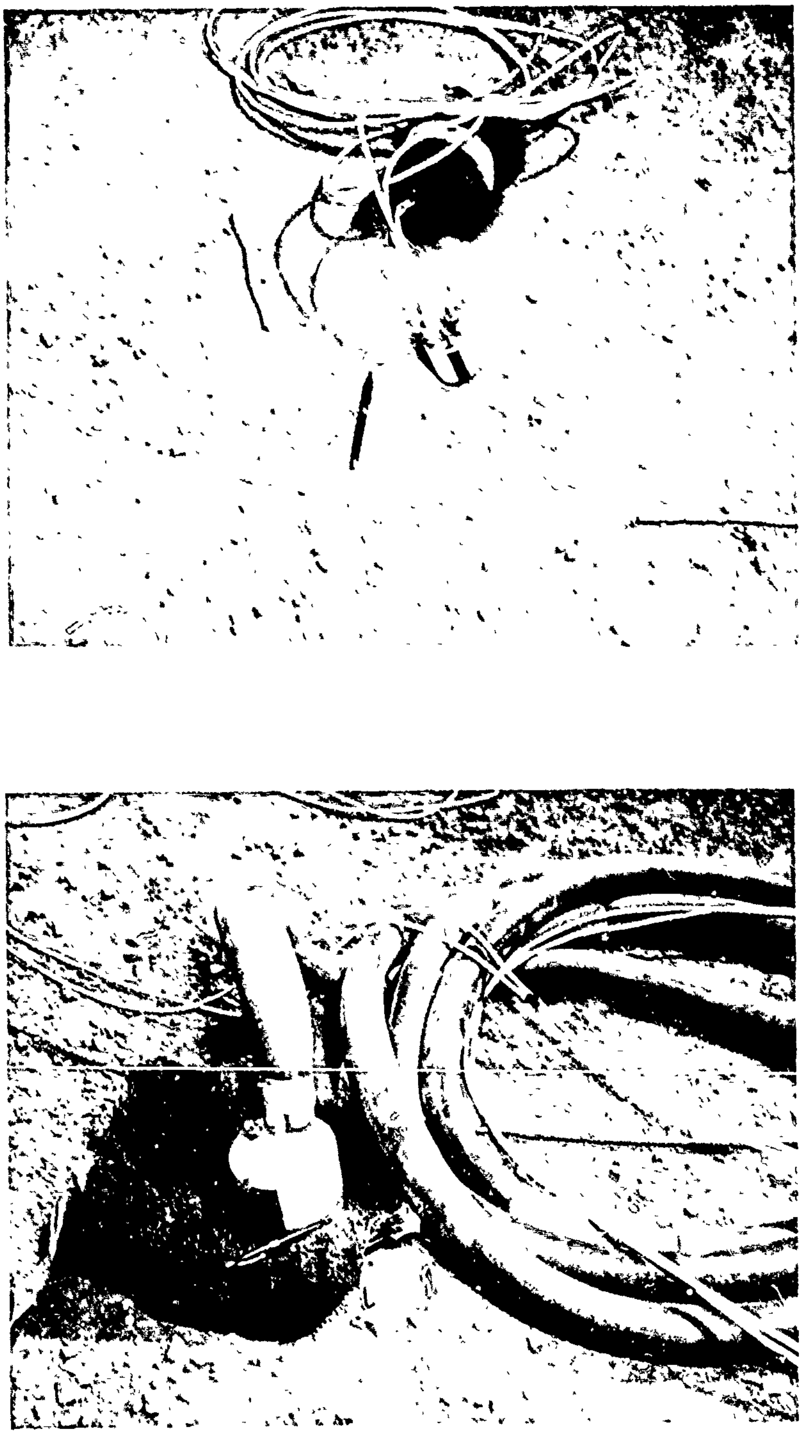


Figure 2-71. WES Ground Motion Gage Canisters, Pre-DICE THROW II

Figure 2-72. WES Gages, Stress Gage (Top Photo), Velocity Gage Canister (Bottom Photo), Pre-DICE THROW II

EXPERIMENT DESCRIPTION: The permanent displacements were measured by means of displacement pins placed along the profile diameters. Each pin was a 10-in. (25.4-cm) spike driven flush with the ground surface and surveyed preshot and postshot to give elevation and distance from its respective GZ. Changes in position of a pin resulting from a detonation are assumed to be a measurement of the soil permanent surface displacement. The displacements were measured from the crater lip crest out to a radial distance of 500 ft (152.4 m). The pins began at 40 ft (12.19 m) from GZ (just inside the expected crater radius) and extended out to the 500-ft (152.4-m) benchmarks with the following spacing: 3-ft (.91-m) intervals to 100 ft (30.48 m), 5-ft (1.52-m) intervals from 100 to 200 ft (30.48 to 60.96 m), 10-ft (3.05-m) intervals from 200 to 350 ft (60.96 to 106.68 m), and 25-ft (7.62-m) intervals from 350 to 500 ft (106.68 to 152.40 m). This gives 61 pins per radial (244 pins per shot). Elevations were measured by standard leveling techniques, and distances were measured with a Hewlett-Packard 3805A electronic distance measuring device. Accuracy was ± 0.01 ft (3.04×10^{-3} m).

Two radials of sand columns were emplaced on each event. The columns were spaced at 10-ft (3.05-m) intervals from the GZ out to a distance of 80 ft (2.44 m) on both events. Column depths ranged from 25 ft (7.62 m) near GZ to 10 ft (3.05 m) near the crater's edge. On the Pre-DICE THROW II-2 Event, two additional 10-ft (3.05-m)-deep columns were placed on each radial at radial distances of 100 and 120 ft (30.48 and 36.58 m). Below the water table, the columns were filled with precast colored grout cylinders. These cylinders were 6 in. (15.24 cm) in diameter and 1 ft (0.30 m) in length.

The top of each cylinder was surveyed for elevation. Above the grout cylinders, the columns were filled with dyed sand. Metal disk-markers were placed in the sand columns at half-foot increments and surveyed to determine elevation.

The apparent craters were measured by standard leveling techniques along two perpendicular diameters. These diameters were marked by permanent benchmarks, located at 500 and 750 ft (152.40 and 228.60 m) from ground zero on each side. These benchmarks were permanent (set in concrete to protect against disturbance by traffic or other construction activities) and tied in with the overall site control by the support survey. Immediately after the shot, GZs were relocated with transits from the benchmarks. The apparent crater and crater lip were then profiled.

(c) TITLE: Timing and Monitors (DNA Project No. 160-68)

PROJECT OFFICER: Mr. L. Watson

EXPERIMENT DESCRIPTION: Refer to the Timing-and-Firing section of this report.

(d) TITLE: Soil Sampling and Testing*

PROJECT OFFICER: Dr. E. Jackson

OBJECTIVE: Sampling, identifying and testing the materials in the Pre-DICE THROW II test area.

EXPERIMENT DESCRIPTION: Four piezometers were placed in the test-bed to monitor depth-to-water table at each GZ and intermediate points along the main ground-motion gage arrays. In addition, fourteen Standard Penetration Tests (SPTs) were conducted to generally classify material

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*Refer to WES Reports: Material Property Investigation for Pre-DICE THROW I and II: Results from the Subsurface Exploration Programs, June 1976 and Material Property Investigation for Pre-DICE THROW I and II: Results from Laboratory Testing Programs, November 1976.

response and examine the test bed for material variations. Boring logs were obtained from both the SPT holes and from eleven undisturbed sample holes. The location and identification of this sampling, SPTs and piezometer borings, are shown in The Preliminary Results Report, POR #6904 and in Figure 2-73. The deepest undisturbed sample was taken at a depth of approximately 400 ft (121.92 m). The majority of the borings extended from the ground surface to a depth of 50 ft (15.24 m). In addition, there were two geophysical holes placed near the main ground-motion gage-line for Event 1. Measurements in these borings were intended to address cross-hole and uphole seismic profiles and to attempt a shear-wave enhancement technique to identify shear-wave velocities in the materials. In addition, a Birdwell boring log was taken in boring U-1.

18. White Sands Missile Range (WSMR)

(a) TITLE: Project Support
PROJECT ENGINEER: Mr. R. Dysart
UP-RANGE FACILITY ENGINEER: Mr. D. Green
SUPPORT DESCRIPTION: The WSMR provided construction support, TNT charge construction support, documentation and supplemental technical photography, security, meteorological support and communications for the Pre-DICE THROW II program.

The WSMR high-speed photographic support was supplied at two camera stations, each separated by 120 degrees from the DRI station and located approximately 4500 ft (1371.6 m) from GZ. Eight cameras ranging in framing rates from 20 to 5000 frames per second were used. The camera details are outlined in Tables 2-19 and 2-20 and pictured in Figure 2-74.

(b) TITLE: Camera Mount Test
PROJECT OFFICER: Mr. J. Gorman

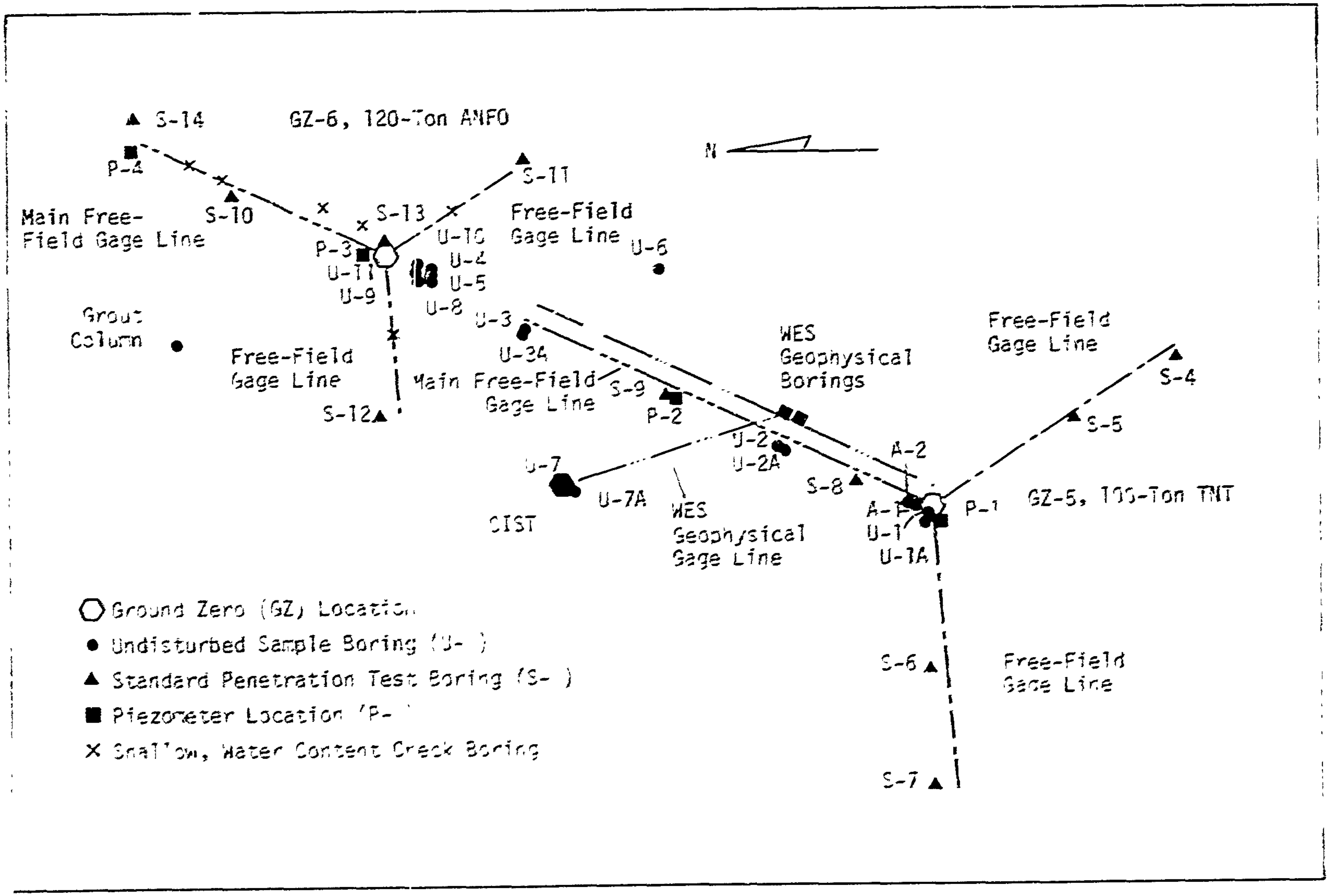

Figure 2-73. WES Soil Sampling Layout, Pre-DICE THROW II Program

Table 2-19. WSMR Technical Photography Details, Pre-DICE THROW II, Event 1

Camera Type	Location*	Framing Rate (frames/sec)	Lens	Film	View
Photosonic 4-C	Site 1	2500	10 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 1	2500	6 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 1	2500	10 in.	35mm	Charge at Bottom Right
Photosonic 10-B	Site 1	360	10 in.	70mm	Charge at Bottom Center
Hycam or Nova	Site 1	5000	3 in.	16mm	Charge at Bottom Left
Photosonic 10-R	Site 4	50	6 in.	70mm	Charge at Bottom Center
Photosonic 4-C	Site 3	2500	6 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 3	2500	10 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 3	2500	6 in.	35mm	Charge at Bottom Right
Hycam or Nova	Site 3	5000	3 in.	16mm	Charge at Bottom Left
Photosonic 4-C	**	2500	20 in.	35mm	Trench 3 Lower Middle

*Site 1 is 4000 ft (1219.20 m) at 0 degrees; Site 3 is 4000 ft (1219.20 m) at 240 d ees; Site 4 is D7 at 13,300 ft (4053.84 m)
**Located approximately 1030 ft (313.94 m) at 135 degrees from GZ5 and will operate on 100-ton (90.7-metric-ton) TNT test only.

NOTE: All stations set for ambient-light exposure. Start and recording times of the high-speed instruments will be contingent on the project start-pulse accuracy.

Table 2-20. WSMR Technical Photography Details, Pre-DICE THROW II, Event 2

Camera Type	Location*	Framing Rate (frames/sec)	Lens	Film	View
Photosonic 4-C	Site 4	2500	80mm	35mm	Charge at Bottom Center
Photosonic 4-C	Site 1	2500	10 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 1	2500	6 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 1	2500	10 in.	35mm	Charge at Bottom Right
Hycam or Nova	Site 1	5000	3 in.	16mm	Charge at Bottom Left
Photosonic 10-R	Site 4	50	7 in.	70mm	Charge at Bottom Center
Photosonic 4-C	Site 3	2500	6 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 3	2500	10 in.	35mm	Charge at Bottom Left
Photosonic 4-C	Site 3	2500	6 in.	35mm	Charge at Bottom Right
Hycam or Nova	Site 3	5000	3 in.	16mm	Charge at Bottom Left

*Site 1 is 4000 ft (1219.20 m) at 0 degrees
Site 3 is 4000 ft (1219.20 m) at 240 degrees
Site 4 is D7 at 13,300 ft (4053.80 m)

NOTE: All stations set for ambient-light exposure. Start and recording times of the high-speed instruments will be contingent on the project start-pulse accuracy.

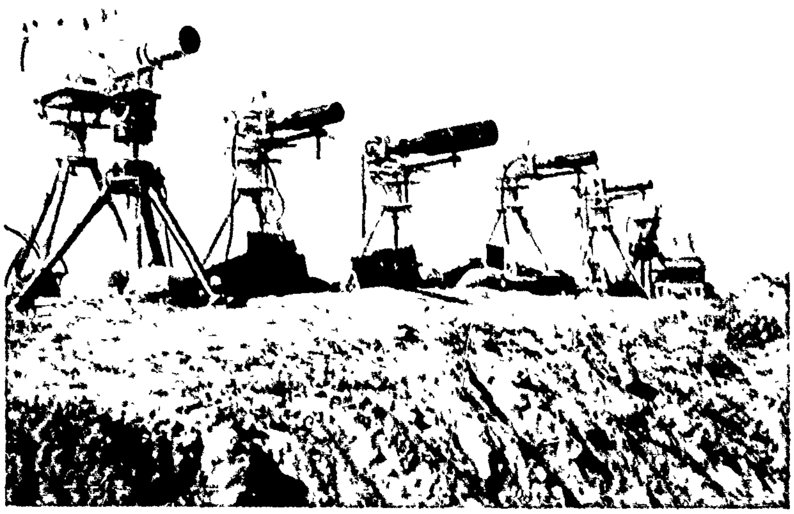

Figure 2-74. WSMR Camera Station on Pre-DICE THROW II

EXPERIMENT DESCRIPTION: A camera mount and camera were placed in the test bed at the 25-psi level to determine its structural response to the ground motion and airblast on Event 2. Refer to photographs in Figure 2-75.

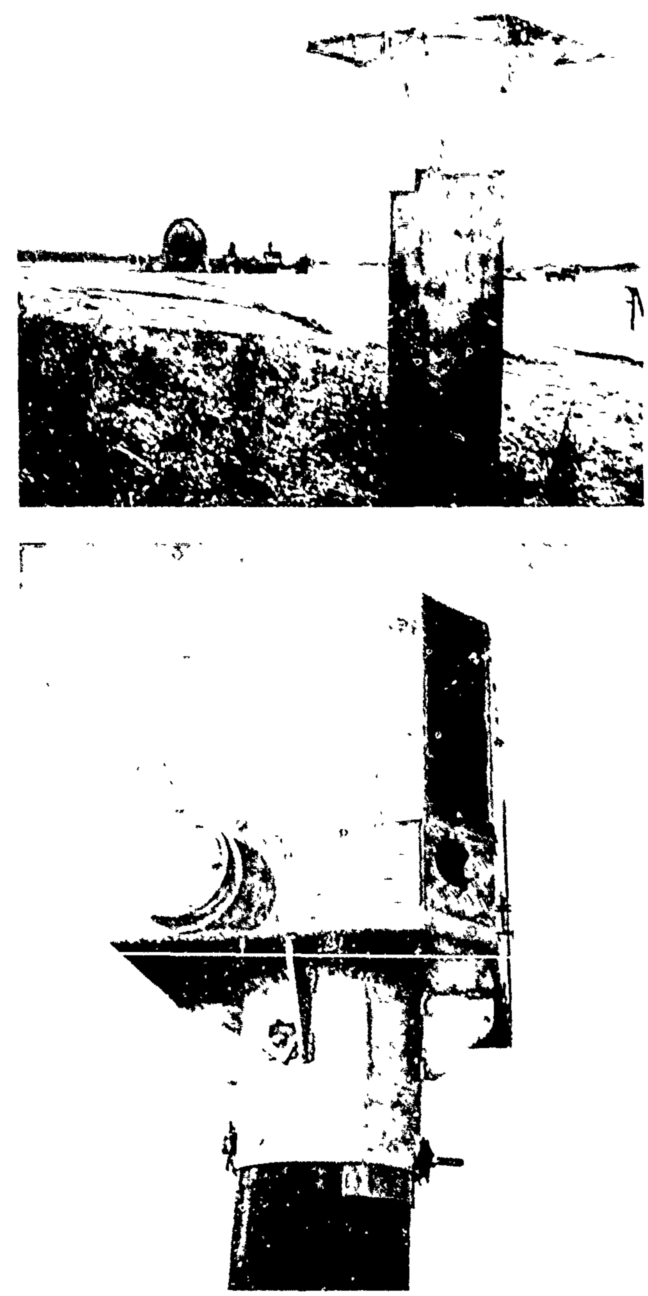

Figure 2-75. WSMR Camera Mount on Pre-DICE THROW II, Event 2

CHAPTER III

DICE THROW TEST EXECUTION REPORT

INTRODUCTION

The DICE THROW event was conducted near the GIANT PATRIOT site on the White Sands Missile Range (WSMR) and was the final test of the DICE THROW program. The charge for this test was composed of approximately 628 tons (570 metric tons) of Ammonium Nitrate Fuel Oil (ANFO and its configurations was a right-circular cylinder, base-tangent to the surface with a hemispherical top, the same configuration as the second event in the Pre-DICE THROW II series. The primary objectives of this test were to provide a simulated nuclear blast and shock environment for target-response experiments that are vitally needed by the military services and defense agencies concerned with nuclear weapons effects, and to confirm empirical predictions and theoretical calculations for blast response of military structures, equipment and weapons systems.

The safety requirements for DICE THROW are located in the following Safety Operating Procedures.

1. SOP 224-51-76, 4 October 1976; Operation No. 2 Pre-Arming (BIS Emplacement), Arming (Firing System Hook-up), Detonation and Final Assembly of Booster Initiation System (BIS).
2. SOP 224-51-76, 20 September 1976; Main Booster Assembly (MBA) Emplacement and Main Charge Construction.
3. SOP 224-50-76, 20 September 1976; Firing of XM-198 and SP-M109 Howitzers (155 mm).

The DICE THROW Safety Plan, 1 June 1976, was also used as a supplement to the HE Test Safety Document.

The security operation procedure followed was SOP TE-1G-380-5a, 21 September 1976, Communication Security COMSEC Standing Operating Procedures. Security personnel were provided by WSMR during the stacking operation and for controlling access to the test bed prior to and after the event.

Survey information pertaining to ground zero and target locations pre- and post-test are located in:

1. Survey No. 296-76, WSD-73 (NAD) DICE THROW 90-mile area, 12 May 1976.
2. Survey No. 306-76, WSD-73 (NAD) DICE THROW 90-mile area, 21 May 1976.
3. Survey No. 397-76, WSD-73 (NAD) Transmitter and Receivers for DICE THROW, 7 July 1976.
4. Survey No. 434-76, WSD-73 (NAD) DICE THROW M109 Impact Point Reference #036070, 28 July 1976.
5. Survey No. 473-76, WSD-73 (NAD) DICE THROW Transmitter, 12 August 1976.
6. Survey No. 574-76, WSD-73 (NAD) Pre-Shot DICE THROW Profile for October 1976, 21 September 1976.
7. Survey No. 613-76, WSD-73 (NAD) M109, M198 Impacts DICE THROW, 7 October 1976.
8. Survey No. 614-76, WSD-73 (NAD) DICE THROW Survey Points Pre-Shot, 13 October 1976.
9. Survey No. 633-76, WSD-73 (NAD) Post-Shot DICE THROW Profile for October 1976, 18 October 1976.
10. Survey No. 636-76, WSD-73 (NAD), M198 #1-M198 #10, M108 #1-M109 #10 (DICE THROW), 22 October 1976.
11. Survey No. 658-76, WSD-73 (NAD) DICE THROW Control Points Post-Shot, 22 October 1976.
12. Survey No. 674-76, WSD-73 (NAD) DICE THROW (90-Mile Area) Pre-Shot, 26 October 1976.
13. Survey No. 686-76, WSD-73 (NAD) DICE THROW Survey Points Post-Shot, 27 October 1976.

These surveys were provided by the Defense Mapping Agency, Geodetic Support Activity Topographic Center, White Sands Missile Range, New Mexico.

The countdown procedure used for the DICE THROW event is located in Appendix B. The DICE THROW Test Engineer's Report is also located in this Appendix. The DICE THROW Summary Schedule is shown in Figure 3-1 and the Testing Area is shown in Figure 3-2.

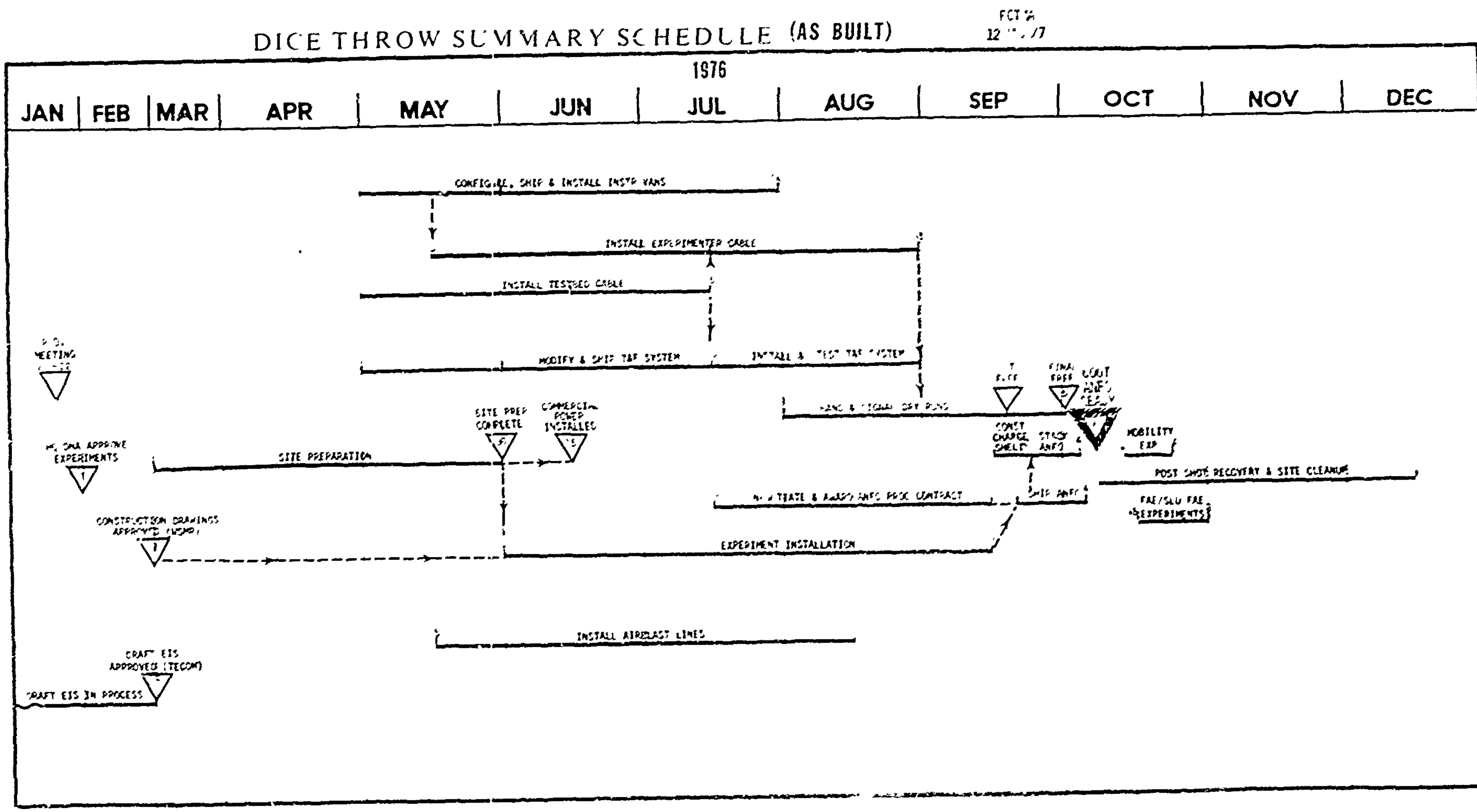

Figure 3-1. DICE THROW Summary Schedule

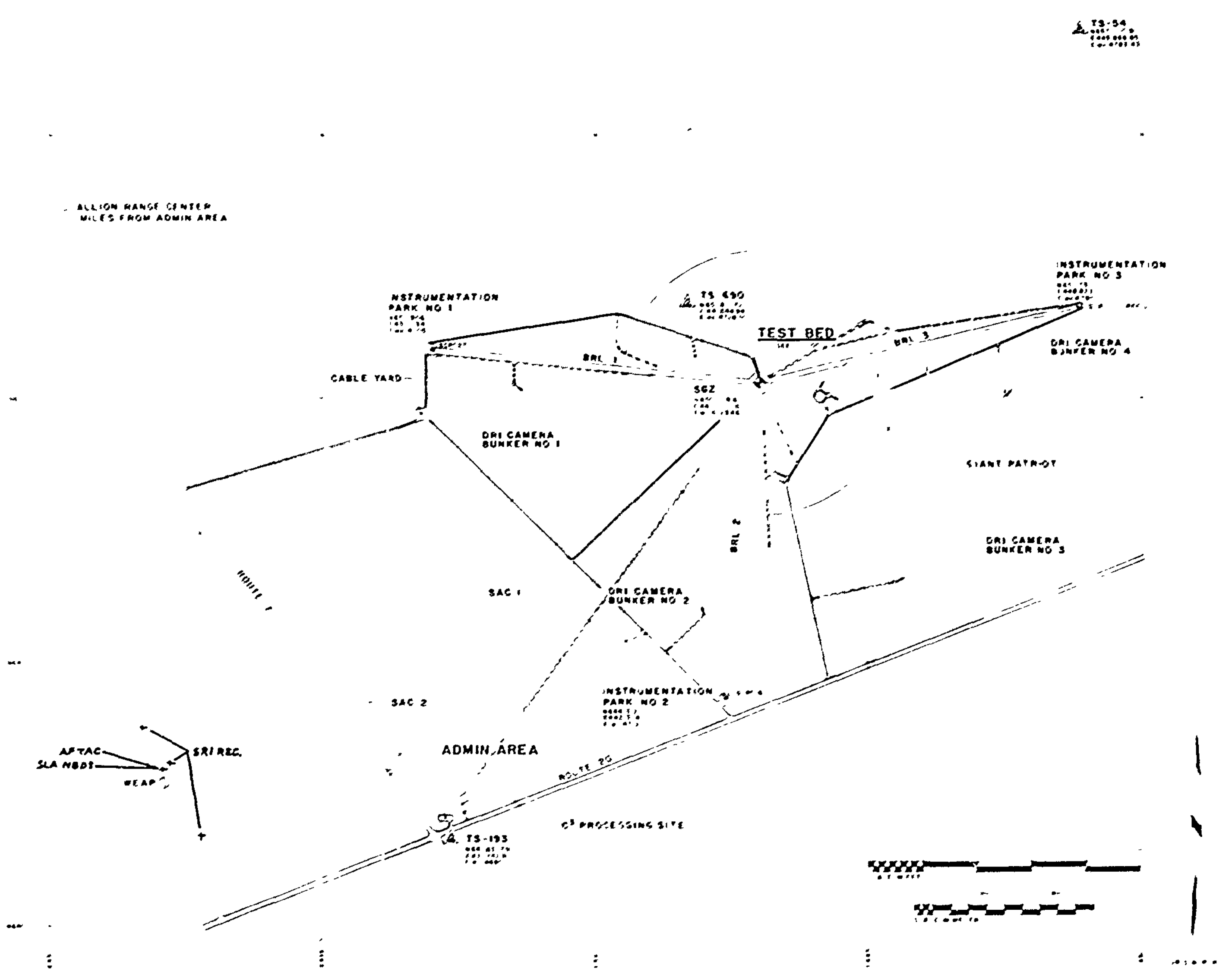

Figure 3-2. DICE THROW Testing Area

DICE THROW TEST GROUP STAFF (Refer to Figure 3-3)

LCDR E. W. Edgerton, USN (505) 264-4651

Test Group Director

LCDR J. D. Strode, CEC, USN (505) 264-4651

Deputy Test Group Director

Vehicle Control Officer

Program Coordinator for:

*Blast Effects on U. S. Wheeled Vehicles (BRL)

**Charge/Detonation System Construction (NSWC/CERF)

*Blast Effects on Army Operationally Oriented Weapons Systems (ARMCOM/WSMR)

**Timing and Firing (DRES/LLL)

Armored Personnel Carrier (Netherlands)

**Air Blast Damage Predictions (SLA)

**Particle and Detonation Velocity Measurement (LLL)

Wall Response (SRI/BRL)

Industrial Equipment (Boeing)

Component Test (GM)

Component Test (Chrysler)

7th Special Forces Group (SFG)

MAJ R. G. Palaschak, USA (505) 264-4651

Security Officer

Safety Officer

**Documentary Photography

Program Coordinator for:

Seismic Measurements (AFWL/ERIM/SMU)

*Blast Effects on In-Flight Helicopter (BRL)

**Dynamic Airblast Measurements (BRL)

Army Personnel Shelters (WES)

Blast Tests of Expedient Shelters (ORNL/ERDA)

**Aircraft Overpressure Vulnerability (NWEF)

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*DNA Supported

**DNA Funded

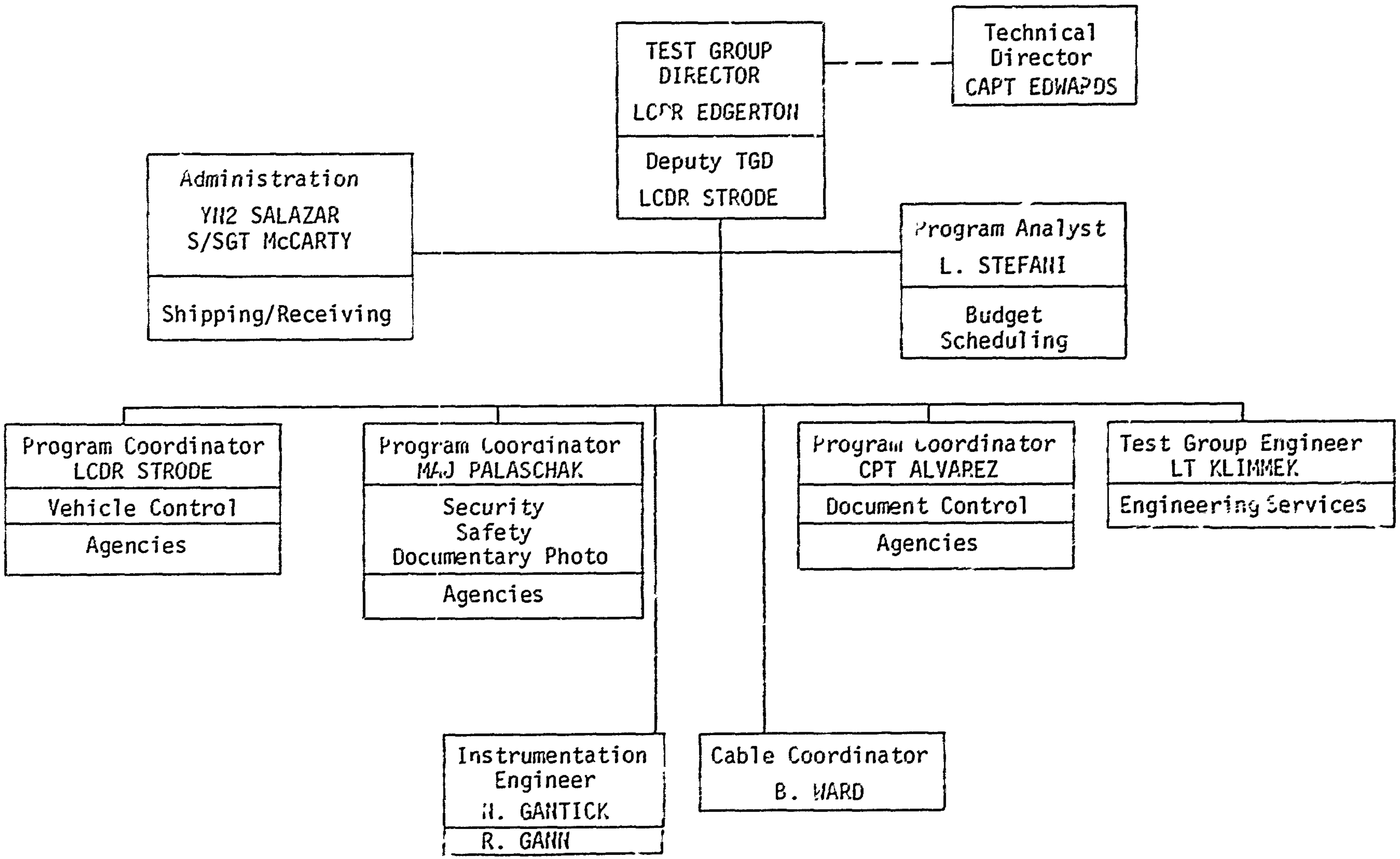


Figure 3-3. DICE THROW Organization

Shelter Exposure to Ground Shock and Air Blast (FRG/WES)

Blast Door Response (NOR/CERF)

Shelters (Sweden/CERF)

Low Light TV and IR Scanner Observations (SAC)

**Technical Photography (DRI)

**Overhead Technical Photography (Williamson/USGS)

CPT V. A. Alvarez, USA (505) 264-4651

Document Control Officer

Program Coordinator for:

Fireball Measurement Techniques (AFTAC)

*Vulnerability and Hardening of CCC Shelter Systems (BRL)

Mobility Experiments (WES)

**RF Transmission Experiment (SRI)

**Blast Displacement Effects in Field Fortifications (LF)

Blast Response of Slatted Antenna, Integrated Masts and Vented Radomes (ASWE-UK)

Blast Response of Navy Masts (DRES-CAN)

*AF Aircraft Structures (AFWL)

Nuclear Blast Detection Systems (SLA)

CPT T. Y. Edwards, USAF (505) 264-4651

Technical Director

**Airblast Predictions (BRL/AFWL)

Seismic Predictions (DNA)

Crater Predictions (DNA)

**Explosive Diagnostics (LLL)

**Documentation (GE TEMPO)

Ejecta Collection and Displacement Pins (CERF/AFWL)

LT C. A. Klimmek, CEC, USN (505) 264-8261

Test Group Engineer

**Engineering Services (KOA)

Mr. L. J. Stefani (505) 264-7804

Program Analyst

Budget Preparation

Schedule Preparation

Mr. N. A. S. Gantick (505) 264-7888

Instrumentation Engineer

Mr. R. L. Ward (EG&G, Inc.) (702) 986-9252

**Cable Coordinator

YN1 J. E. Salazar, USN (505) 264-4651

SSGT P. McCarty, USAF (702) 986-9252

Adminstrative Specialists

Shipping/Receiving Coordinator

EXPERIMENTS AND SUPPORT AGENCIES (Re... to Figure 3-4)

1. Air Force Technical Application Center (AFTAC)
2. Air Force Weapons Laboratory (AFWL)
3. Ballistic Research Laboratory (BRL)
4. Bendix Field Engineering Corp.
5. Bob Rutherford Construction Co.
6. Boeing Aerospace Company
7. Canada - Defense Research Establishment Suffield (DRES)
8. Chrysler - Chrysler Defense Division (CDD)
9. Denver Research Institute (DRI)
10. EG&G, Inc.
11. Environment Research Institute of Michigan (ERIM)
12. Falcon, Inc.
13. General Electric Company - TEMPO
14. General Motors (GM)/Detroit Diesel Allison
15. Germany (FRG) - Bundewehr
16. Ken O'Brien and Associates (KOA)
17. Lawrence Livermore Laboratory (LLL)
18. Lovelace Foundation (LF)
19. Naval Surface Weapons Center (NSWC)
20. Naval Weapons Evaluation Facility (NWEF)
21. Netherlands (GON) - Technologisch Laboratorium (TNO)
22. Norway - Norwegian Defense Construction Service (NDCS)
23. Oak Ridge National Laboratory (ORNL)
24. Rodman Laboratory - U.S. Army Armament Commend (ARMCOM)
25. Sandia Laboratory Albuquerque (SLA)
26. Socorro Power and Electric Coop., Inc.

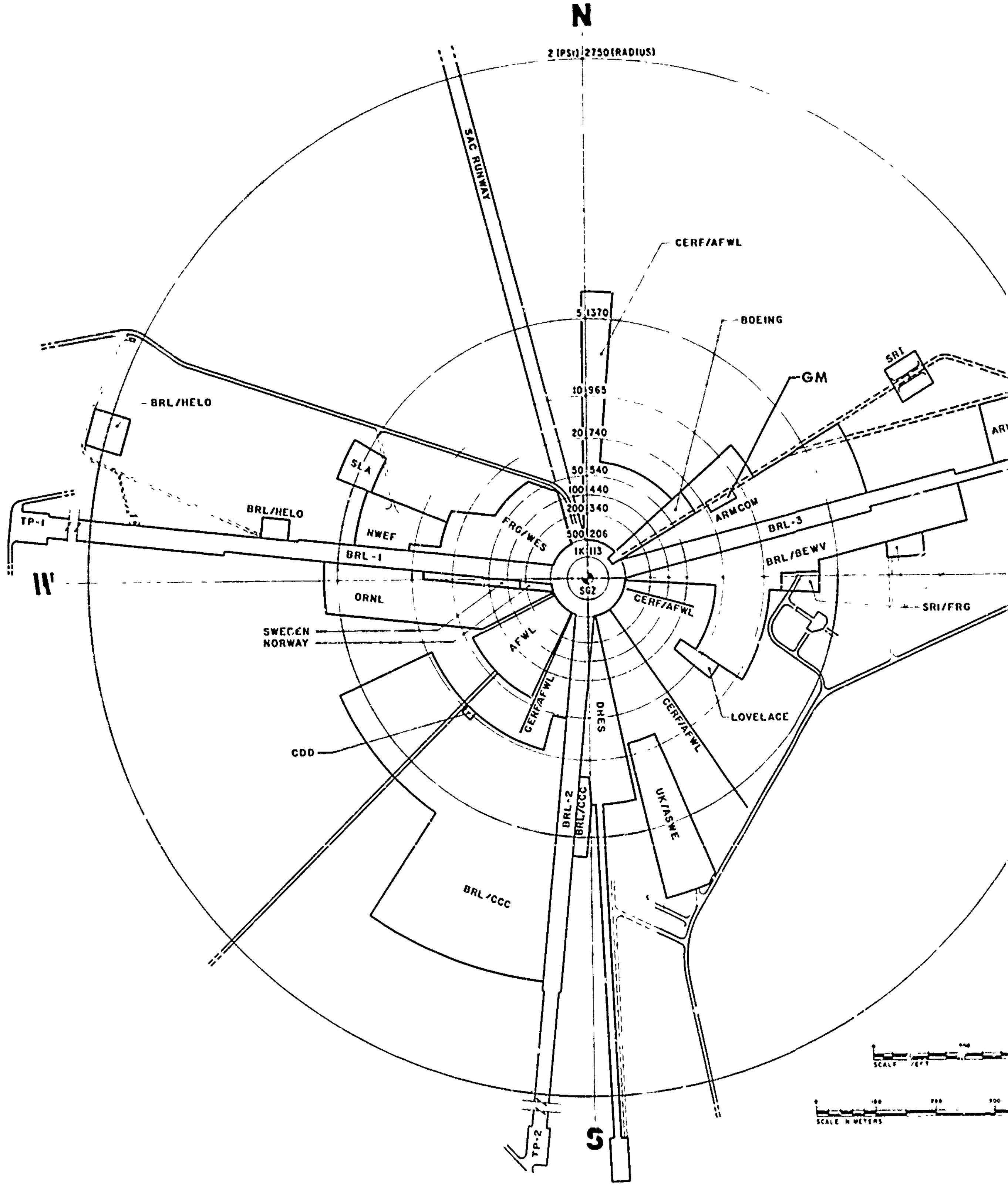
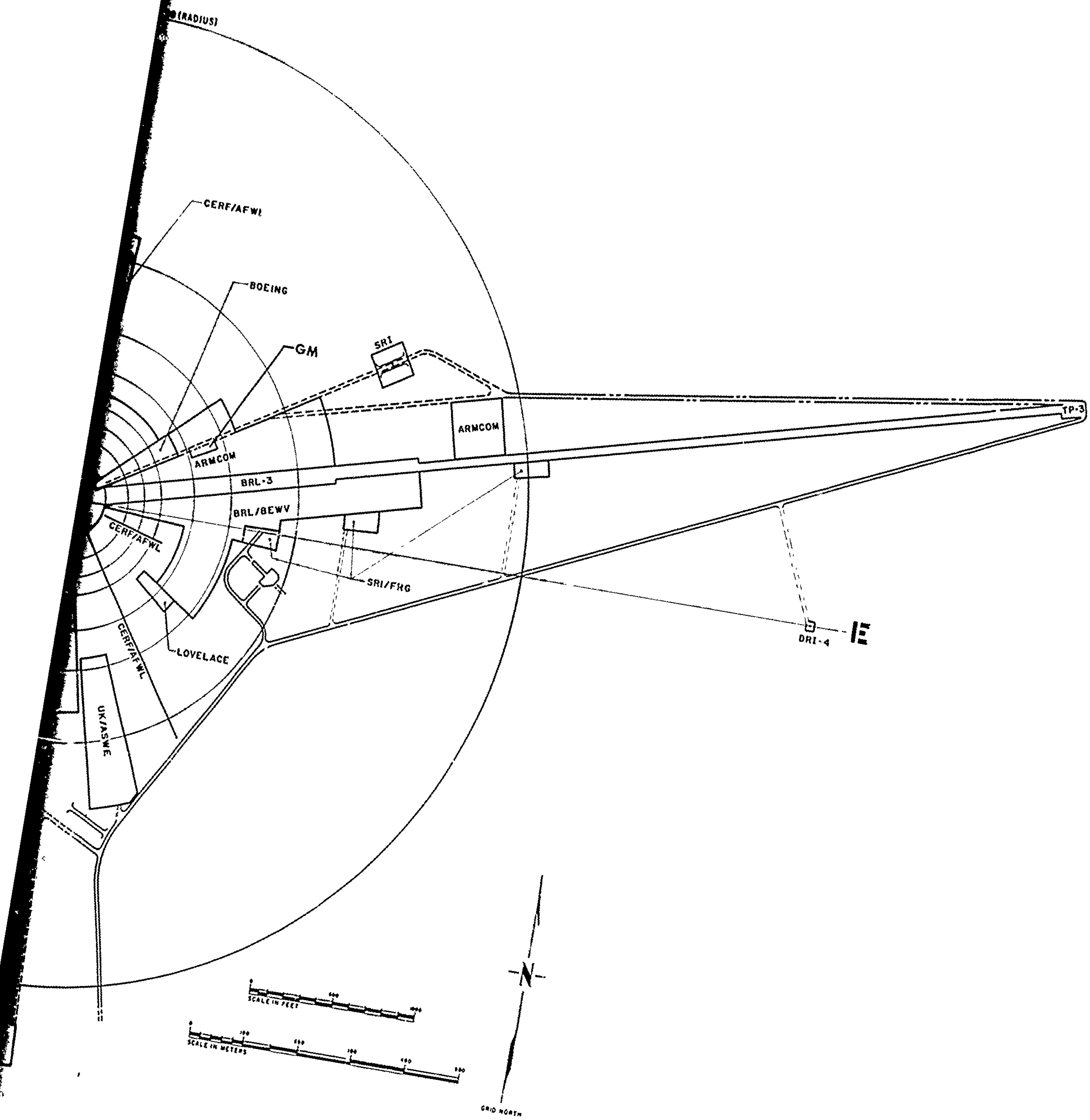


Figure 3-4. Test Bed Layout on DICE THROW



(RADIUS)
CERF/AFWL
BOEING
GM
SRI
ARMCOM
ARMCOM
TP-3
BRL-3
BRL/BEWV
CERF/AFWL
SRI/FHG
LOVELACE
CERF/AFWL
UK/ASWE
DRI-4
E
N
SCALE IN FEET
SCALE IN METERS
GRID NORTH

2

27. Southern Methodist University (SMU)
28. 7th Special Forces Group
29. Stanford Research Institute (SRI)
30. Strategic Air Command (SAC)
31. Sweden - Royal Swedish Fortification Administration (RSFA)
32. United Kingdom (UK)/Admiralty Surface Weapons Establishment (ASWE)
33. University of New Mexico Civil Engineering Research Facility (CERF)
34. U. S. Army Electronics Command (ECOM)
35. U. S. Army Engineer Waterways Experiment Station (WES)
36. U. S. Army White Sands Missile Range (WSMR)
37. Williamson Aircraft Company

SITE LOCATION AND DESCRIPTION (Refer to Figure 3-5)

The DICE THROW event was conducted on the WSMR at the GIANT PATRIOT site which is located 12 miles (20.9 km) southeast of the Stallion Range Center in the northern portion of the range and approximately 100 miles (161 km) north of the main post area. The site is at an elevation of 4730 ft (1442 m) above sea level in the northern portion of the Jornada del Muerto Basin. The test area is flat, and the nearest mountains are approximately 8 miles (12.9 km) to the east. The site lies within the Sonoran Life Zone of a northern extension of the Chihuahuan Desert. It is categorized as a gypsum grasslands and dunes association near a sand grasslands and dunes association, the two most abundant vegetation associations on WSMR. The immediate area of the test site is largely chamisa, grasses and isolated yucca plants.

The site climate is typical of semi-arid areas of the southwest desert. Days are typically sunny, and annual rainfall averages from less than 8 in. (20.3 cm) in the basin to more than 16 in. (40.6 cm) in the mountains. The winds are normally from the west during the dry months and are frequently gusty. During the summer and fall months, moist tropical air masses intrude from the Gulf of Mexico causing prevailing winds from the southeast, frequent thundershowers and electrical atmosphere disturbances. The highest wind speeds occur in the spring when dust storms are common.

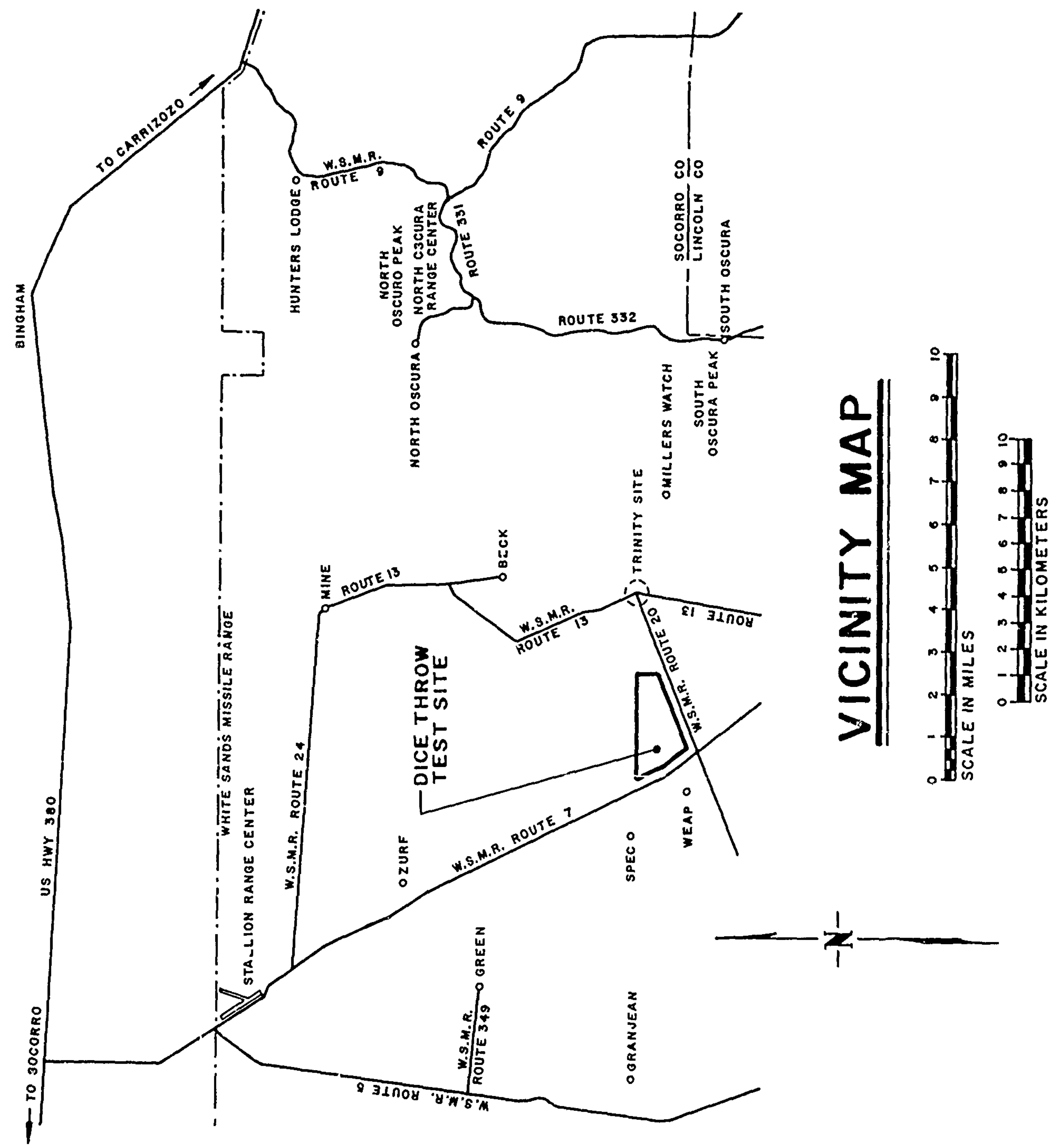


Figure 3-5. DICE THROW Site Location

Copper, lead, and other minerals exist in the nearby mountains and large amounts of gypsum are present. The watertable is variable in the area, 80 feet (24.4 m) or greater, and sand water movement is slowly westward to the Rio Grande River. Bedrock at the site is greater than 200 ft (61.0 m) below the surface.

CHARGE DESCRIPTION

The DICE THROW ammonium nitrate fuel oil (ANFO) charge design (stacking plan), stacking and charge shelter system were provided by the Civil Engineering Research Facility (CERF) under the supervision of Mr. K. Bell and Dr. G. Lane.

Mr. Mike Swisdak of the Naval Surface Weapons Center (NSWC) was responsible for the specifications of the ANFO, monitoring the internal temperature of the stack, the design and fabrication of the charge detonation systems and monitoring the fuel oil content and particle size distribution of the ANFO in the charge.

The stacking plan was based on the same design used for the Pre-DICE THROW II, Event 2 charge (120-ton (108.9-metric ton) ANFO charge). The charge shape was a surface tangent (base), 628.27-ton (569.97-metric ton) ANFO, multiple-detonated, domed (cap) cylinder with a length to diameter (cylindrical section) of 0.75 to 1.00. Refer to the photo in Figure 3-6.

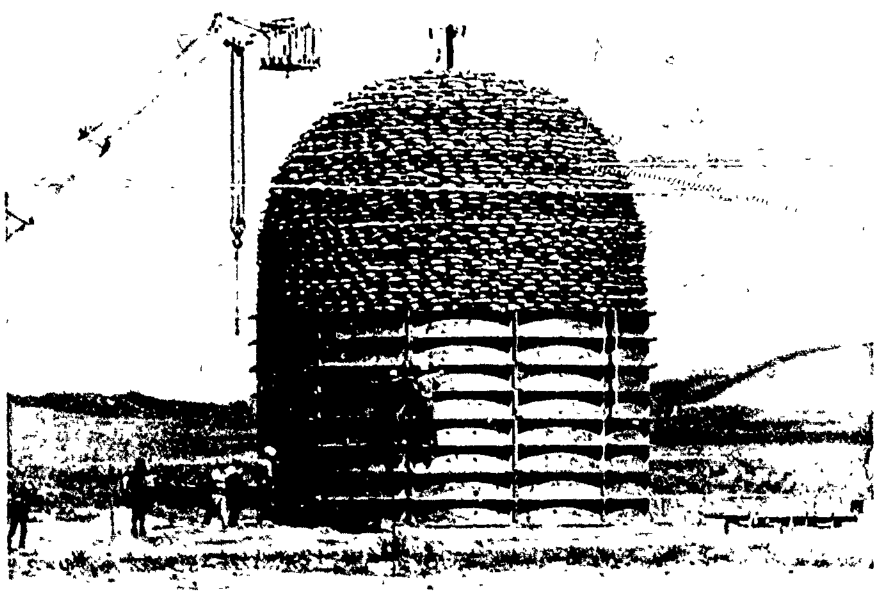


Figure 3-6. Completed DICE THROW ANFO Charge

It was constructed of layers of 50-lb (22.7-kg) bags of ANFO with all voids (spaces between bags) filled with loose ANFO. Refer to Table 3-1 for the physical dimensions of the completed charge.

The ANFO was procured from two distributors: the H and N Company of Carlsbad, New Mexico, for Gulf Oil, and Bud Walter, Inc. of Estancia, New Mexico for Atlas. Delivery of the ANFO to the test site was by tractor trailers (26 loads). Refer to Table 3-2 for details pertaining to ANFO deliveries. The off-loading of the ANFO during the charge stacking phase was accomplished using a roller-conveyer onto an electric hydraulic conveyor to the charge (refer to the right photo in Figure 3-7).

The charge was stacked on a plywood base 2-1/4 in. (5.72 cm) thick. Circular forms, in 4-ft (1.22-m) sections, constructed of 3/8-in. (0.95-cm) thick plywood with 2x12-in. (5.08x30.48-cm) stiffeners, were emplaced around the charge during stacking to control the charge diameter and aid in keeping the stack plumb. Refer to the left photo in Figure 3-7. The outer two bags of ANFO of each layer were glued to prevent the bags from slipping. The type of glue used was Polycrinyl Acetate Emulsion Adhesive (Gulf lot #B-3252). A charge shelter system was constructed around the charge to protect against rain, wind and lightning (refer to Figure 3-8). There were delays in the stacking schedule due to problems with the erection of this protection system and also with ANFO deliveries because of a breakdown of equipment at the H and N Company in Carlsbad. The time was made up, however, due to the hard work and long

Table 3-1. Physical Dimensions of Completed Charge

Diameter	29.70 ft	(9.05 m)
Cylinder Height	22.28 ft	(6.79 m)
Cap Radius	14.85 ft	(4.53 m)
Total Charge Height	37.13 ft	(11.32 m)
Layers in Cylinder	≈ 52	
Layers in Cap	≈ 35	

Table 3-2. DICE THROW ANFO Deliveries

Load #	# of Bags ANFO	Total Wt (lbs)	of Load (kg)	Date Delivered	Supplier
1	1000	50,000	22,680	9/20/76	H & N Co.
2				9/20/76	
3				9/21/76	
4				9/22/76	
5				9/24/76	
6				9/24/76	
7				9/25/76	
8				9/25/76	
9				9/25/76	
10				9/26/76	
11				9/27/76	
12				9/27/76	
13				9/28/76	
14				9/28/76	
15				9/28/76	
16				9/29/76	
17				9/29/76	
18				9/29/76	
19				9/30/76	
20	840	42,000	19,050	10/01/76	Bud Walter, Inc.
21	840	42,000	19,050	10/02/76	Bud Walter, Inc.
22	1000	50,000	22,680	10/02/76	H & N Co.
23	800	40,000	18,144	10/02/77	H & N Co.
24	840	42,000	19,050	10/02/77	Bud Walter, Inc.
25	840	42,000	19,050	10/02/77	Bud Walter, Inc.
26	840	42,000	19,050	10/02/77	Bud Walter, Inc.
TOTAL*	25,000	625 tons	567 metric tons		

*107 bags of ANFO were returned to supplier (2.675 tons (2.427 metric tons)) = 622.325 tons (564.57 metric tons)

Figure 3-7. Off-Loading and Loading of ANFO from Trailer During Stacking (Right Photo); Forms Used for Quality Control and Safety (Left Photo)—DICE THROW

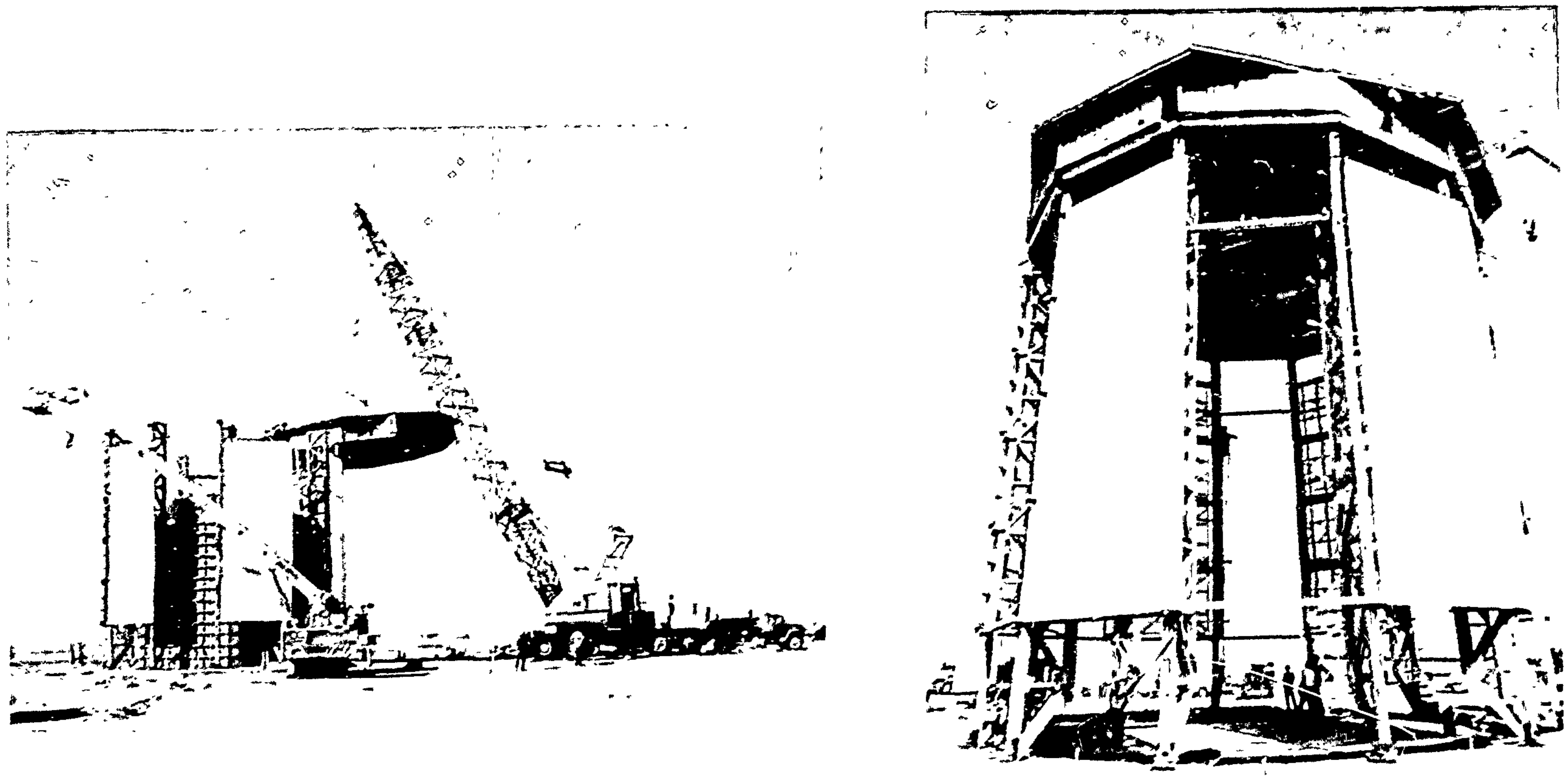


Figure 3-8. Charge Shelter System (Right Photo); Dismantling of the System after Completion of Stacking (Left Photo)—DICE THROW

hours of the DNA staff and CERF construction and stacking crews. Approximately 216 hours were required in stacking using two shifts (9 men on day shift, 10 men on night shift).

The boostering and initiation systems were also based on the designs used for the Pre-DICE THROW II, Event 2. The Main Booster Assembly (MBA) was emplaced during charge construction (refer to the top photo in Figure 3-9), and the Booster Initiation System (BIS) was lowered into position during Pre-Arming (refer to the bottom photo in Figure 3-9). Detail drawings of these systems are referenced in Appendix A. The system layouts were similar to those depicted in Figures 2-11 and 2-13 in Chapter 2.*

During stacking, the air temperature and internal-stack temperature were monitored with a dual-channel thermistor recorder. The stack sensor was located in the sixth layer above the ground, approximately 9 ft (2.74 m) from the edge of the stack. The air-temperature sensor was located approximately 10 ft (3.05 m) above the ground inside the protective structure. The temperature extremes recorded outside the stack were 86° F (30° C) and 55° F (12.8° C) and inside the stack were 74° F (23.3° C) and 78° F (25.6° C) over the time period between 24 September and 5 October 1976.

Samples of ANFO were taken from each layer of the stack and analyzed for fuel oil content and particle-size distribution of the ANFO prills. Table 3-3 presents information relevant to each layer of the charge and Tables 3-4 and 3-5 present the charge weights and material properties, respectively. Refer to the photos in Figure 2-16 in Chapter 2 depicting the quality control procedure.

*Seven octol boosters were installed during stacking around the MBA, each weighing 29.143 lbs (13.22 kg). Each of the seven pentolite boosters weighed 2.14 lbs (0.97 kg). The pentolite boosters with two detonators each were inserted into the BIS at positions vertically identical to the octol boosters.

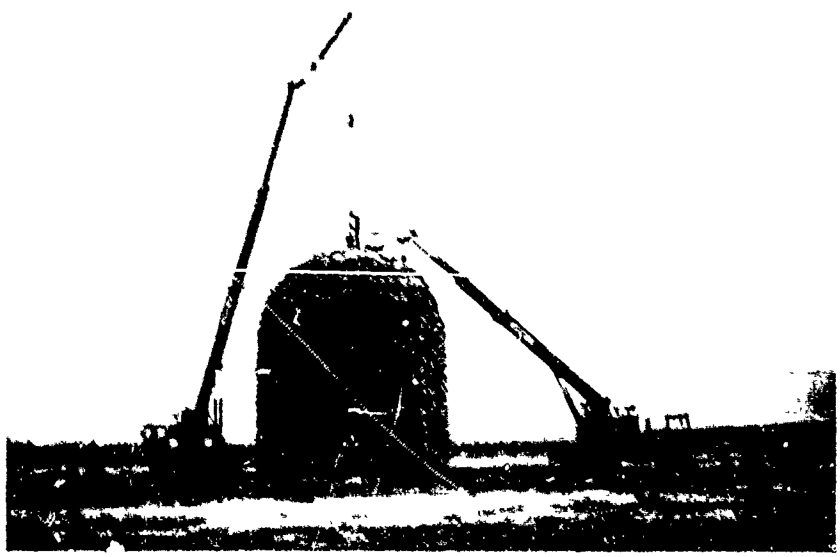


Figure 3-9. Placement of Octol Booster on Main Booster Assembly During ANFO Stacking (Top Photo), Dry-run Placement of Booster Initiation System in Completed ANFO Charge (Bottom Photo), on DICE THROW

Table 3-3. Stacking Data

Layer Number	Layer Radius (ft)	Layer Radius (m)	Number of Whole Bags	Number of Bags Bulk	Total Bags	Average Bag Weight (lb)	Average Bag Weight (kg)	Total Layer Weight (tons)	Total Layer Weight (metric tons)	Average Fuel Oil Content ([illegible])
1	14.85	4.53	298	25	323	50.08	22.72	8.081	7.3[illegible]	6.39
2			291	34	325	49.43	22.42	8.023	7.278	6.25
3			299	26	325	50.04	22.70	8.124	7.370	6.38
4			291	34	325	50.61	22.96	8.215	7.453	5.92
5			287	36	323	50.54	22.92	8.152	7.395	6.45
6			285	35	320	50.00	22.68	7.991	7.249	5.85
7			298	27	325	49.75	22.57	8.077	7.327	6.73
8			296	30	326	50.17	22.76	8.170	7.412	6.22
9			294	33	327	50.79	23.04	8.295	7.525	7.02
10			299	26	325	50.17	22.76	8.146	7.390	5.59
11			308	27	335	50.21	22.77	8.403	7.623	5.89
12			303	26	329	49.71	22.55	8.170	7.412	5.80
13			295	30	325	50.75	23.02	8.239	7.474	6.00
14			300	25	325	50.58	22.94	8.213	7.451	5.87
15			300	25	325	50.32	22.82	8.170	7.412	4.96
16			297	31	328	51.04	23.15	8.362	7.586	6.51
17			303	27	330	50.75	23.02	8.366	7.590	6.41
18			306	25	331	50.17	22.76	8.296	7.526	6.00
19			307	21	328	51.88	23.53	8.503	7.714	6.96
20			300	25	325	50.63	22.97	8.221	7.458	6.66
21			307	25	332	50.88	23.08	8.439	7.656	6.66
22			305	25	330	50.50	22.91	8.326	7.553	6.21
23			306	25	331	50.25	22.79	8.310	7.539	6.27
24			298	30	328	50.23	22.78	8.230	7.466	5.97
25			304	25	329	50.21	22.77	8.253	7.487	6.16

Table 3-3. Stacking Data (Continued)

Layer Number	Layer Radius (ft)	Layer Radius (m)	Number of Whole Bags	Number of Bags Bulk	Total Bags	Average Bag Weight (lb)	Average Bag Weight (kg)	Total Layer Weight (tons)	Total Layer Weight (metric tons)	Average Fuel Oil Content (%)
26	14.85	4.53	301	25	326	50.42	22.87	8.212	7.450	6.23
27			300	25	325	50.58	22.94	8.213	7.451	6.01
28			301	25	326	50.75	23.02	8.266	7.499	5.83
29			304	29	333	50.65	22.97	8.425	7.643	5.99
30			297	25	322	50.19	22.77	8.074	7.325	6.09
31			305	25	330	50.67	22.98	8.354	7.579	6.34
32			306	25	331	50.00	22.68	8.268	7.501	6.83
33			304	27	331	50.33	22.83	8.322	7.550	6.73
34			298	25	323	50.75	23.02	8.189	7 429	6.36
35			297	25	322	51.54	23.38	8.291	7.522	6.07
36			300	25	325	50.79	23.04	8.247	7.482	5.99
37			305	25	330	52.00	23.59	8.573	7.777	6.09
38			300	25	325	49.75	22.57	8.078	7.328	6.03
39			299	25	324	51.00	23.13	8.255	7.489	5.71
40			298	25	323	50.08	22.72	8.081	7.331	6.26
41			298	25	323	49.67	22.53	8.015	7.271	6.11
42			297	26	323	50.42	22.87	8.136	7.381	6.17
43			309	25	334	50.88	23.08	8.490	7.702	6.08
44			304	21	325	51.25	23.25	8.322	7.550	6.18
45			304	21	325	52.42	23.78	8.513	7.723	6.28
46			302	23	325	50.42	22.87	8.187	7.427	6.11
47			310	19	329	52.00	23.59	8.549	7.756	6.31
48			307	18	325	51.92	23.55	8.432	7.650	6.11
49			303	22	325	50.88	23.08	8.262	7.495	6.29
50			298	29	327	51.25	23.25	8.372	7.595	6.63

Table 3-3. Stacking Data (Continued)

Layer Number	Layer Radius (ft)	(m)	Number of Whole Bags	Number of Bags Bulk	Total Bags	Average Bag Weight (lb)	(kg)	Total Layer Weight (tons)	(metric tons)	Average Fuel Oil Content (%)
51	14.85	4.53	296	24	320	52.00	23.59	8.314	7.542	6.20
52	14.85	4.53	297	24	321	48.63	22.06	7.799	7.075	6.19
53	14.85	4.53	304	21	325	49.38	22.40	8.019	7.275	6.46
TOTAL FOR CYLINDER			15921	1377	17298			437.031	396.475	
54	14.85	4.53	307	20	327	50.25	22.79	8.210	7.448	6.12
55	14.85	4.53	309	16	325	52.00	23.59	8.446	7.662	6.47
56	14.85	4.53	303	20	323	50.04	22.70	8.076	7.327	6.81
57	14.85	4.53	306	19	325	50.60	22.95	8.217	7.454	5.76
58	14.85	4.53	306	19	325	51.17	23.21	8.310	7.539	6.62
59	14.69	4.48	324	7	331	50.08	22.72	8.286	7.517	5.50
60	14.69	4.48	273	25	298	50.50	22.91	7.518	7.728	5.25
61	14.69	4.48	261	20	281	50.33	22.83	7.066	7.317	5.71
62	14.45	4.40	264	20	284	50.00	22.68	7.095	7.344	6.00
63	14.34	4.37	264	20	284	49.75	22.57	7.059	7.311	5.80
64	14.21	4.33	257	20	277	49.71	22.55	6.879	6.241	5.49
65	14.21	4.33	269	23	292	50.12	22.73	7.311	6.633	5.94
66	14.08	4.29	266	21	287	49.83	22.60	7.145	6.482	6.04
67	13.92	4.24	257	24	281	48.88	22.17	6.861	6.224	6.18
68	13.76	4.19	247	27	274	49.79	22.58	6.814	6.182	6.02
69	13.58	4.14	238	20	258	49.96	22.66	6.439	5.841	5.92
70	13.38	4.08	229	20	249	49.20	22.32	6.120	5.552	5.75

Table 3-3. Stacking Data (Continued)

Layer Number	Layer Radius (ft)	Layer Radius (m)	Number of Whole Bags	Number of Bags Bulk	Total Bags	Average Bag Weight (lb)	Average Bag Weight (kg)	Total Layer Weight (tons)	Total Layer Weight (metric tons)	Average Fuel Oil Content (%)
71	13.16	4.01	218	20	238	49.67	22.53	5.905	5.357	6.11
72	12.93	3.94	227	15	242	50.79	23.04	6.142	5.572	5.99
73	12.67	3.86	220	0	220	51.00	23.13	5.610	5.089	6.03
74	12.40	3.78	206	1	207	51.25	23.25	5.304	4.812	5.99
75	12.11	3.69	214	0	214	49.25	22.34	5.270	4.781	5.09
76	11.79	3.59	185	0	185	49.62	22.51	4.590	4.164	5.19
77	11.45	3.49	179	0	179	49.33	22.38	4.415	4.005	5.90
78	11.08	3.38	157	1	158	49.62	22.51	3.920	3.556	5.44
79	10.68	3.28	141	0	141	49.92	22.64	3.519	3.192	5.54
80	10.24	3.12	139	0	139	50.92	23.10	3.539	3.211	6.24
81	.77	2.98	128	0	128	50.92	23.10	3.259	2.957	5.89
82	9.26	2.82	129	0	129	50.92	23.10	3.284	2.979	6.02
83	8.69	2.65	102	0	102	50.92	23.10	2.597	2.356	6.19
84	8.06	2.46	91	0	91	51.15	23.20	2.327	2.111	6.03
85	7.36	2.24	75	0	75	51.15	23.20	1.918	1.740	6.13
86	6.54	1.99	58	0	58	51.15	23.20	1.483	1.345	6.37
87	5.58	1.70	42	0	42	51.15	23.20	1.074	0.974	6.12
88	4.38	1.34	26	0	26	51.15	23.20	0.665	0.603	5.93
89	2.60	0.79	10	0	10	51.15	23.20	0.256	0.232	6.14
TOTAL FOR CAP			7227	378	7605			190.930	173.212	
TOTAL FOR CHARGE			23148	1755	24903		.	627.961	569.686	

Table 3-4. Charge Weights - Tons (Metric Tons)

Material	Location		
	Cylinder	Cap	Charge
ANFO	432.732 (392.574)	188.979 (171.442)	621.711 (564.016)
Paper Bags*	4.299 (3.900)	1.951 (1.770)	6.250 (5.670)
Booster	0.109 (0.099)	0 0	0.109 (0.099)
Miscellaneous**	0.15 (0.14)	0.05 (0.05)	0.20 (0.18)
Total	437.290 (396.709)	190.980 (173.257)	628.270 (569.967)

*Average weight of bag is 0.54 lb (0.25 kg)
**PVC pipe, PVC flanges, and bag glue

Table 3-5. ANFO Charge Summary

	Cylinder	Cap	Charge
Total Number of Bags	17,298	7,605	24,903
Total Weight--tons (metric tons)	437.290 (396.709)	190.980 (173.257)	628.270 (569.967)
Volume--ft^3 (m^3)	15,302 (1,422)	6,705 (623)	22,007 (2,405)
Density--g/cm^3	0.915	0.912	0.914
Average Fuel Oil Content (percent by weight)	6.21	5.93	6.12

TIMING, MONITORING AND FIRING SYSTEMS FOR DICE THROW

The Timing and Monitoring Systems were provided by the Defence Research Establishment Suffield (DRES) and installed and operated under the supervision of Mr. Charles Sutherland of Canada. The Firing System was built and installed by the Lawrence Livermore Laboratory under the supervision of Mr. Bernard Hayes.

TIMING AND MONITORING (Refer to Figure 3-10 for main cable layout)

These functions were extremely critical to the success of each experimenter participating in DICE THROW. The testing of these functions with each experimenter was ongoing continuously throughout the fielding operation with problems being identified and solved almost up to shot day.

The type of trailer function monitoring required was temperature, power and tape recorder run/record. Due to cost considerations, each trailer did not have its separate monitoring of these parameters. The only exception to this was the tape recorder run/record. This function was monitored for each trailer separately with the exception of the AFWL's two vans. Even though most experimenters' instrumentation trailers had more than one recorder, only one monitor was used (the run/record contacts of each machine were wired in series). A layout of the trailer monitoring scheme is shown in Figure 3-11.

Approximately 30 different timing signals were distributed to the experimenters via the Timing and Firing Bunker and are described in Figure 3-12. Figure 3-13 (top photo) is a photograph showing the interior of the T & F Bunker during a dry-run. The Countdown Procedures for DICE THROW are contained in Appendix B. A block diagram of the circuitry within the DRES Timing and Firing Bunker is shown in Figure 3-14. Figure 3-13 (bottom photo) shows one of the T & F junction boxes.

FIRING

The T & F Bunker and the LLL instrumentation trailer were both involved in the initiation of the DICE THROW charge (refer to the block diagram in Figure 3-15). LLL was also responsible for: monitoring the

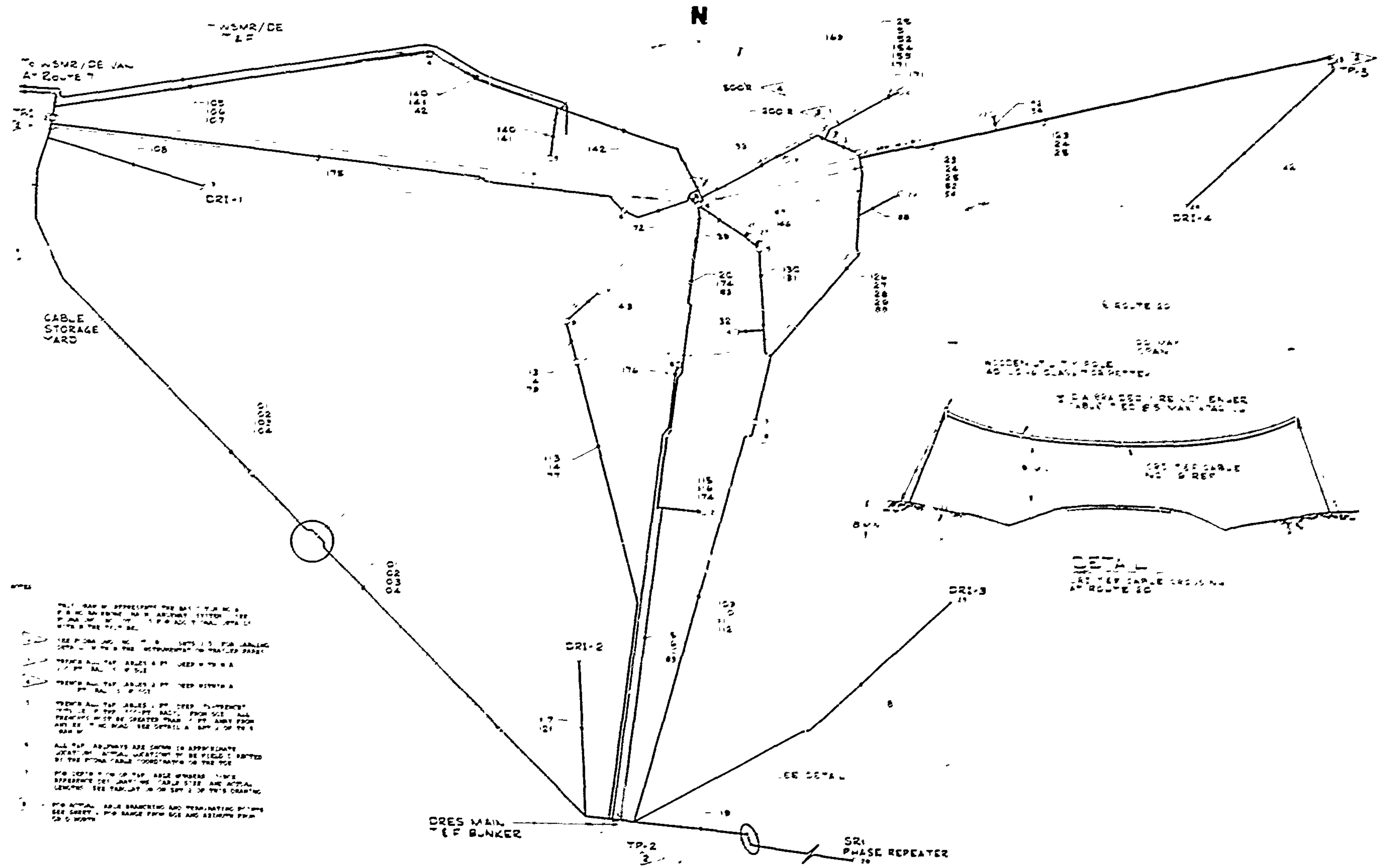
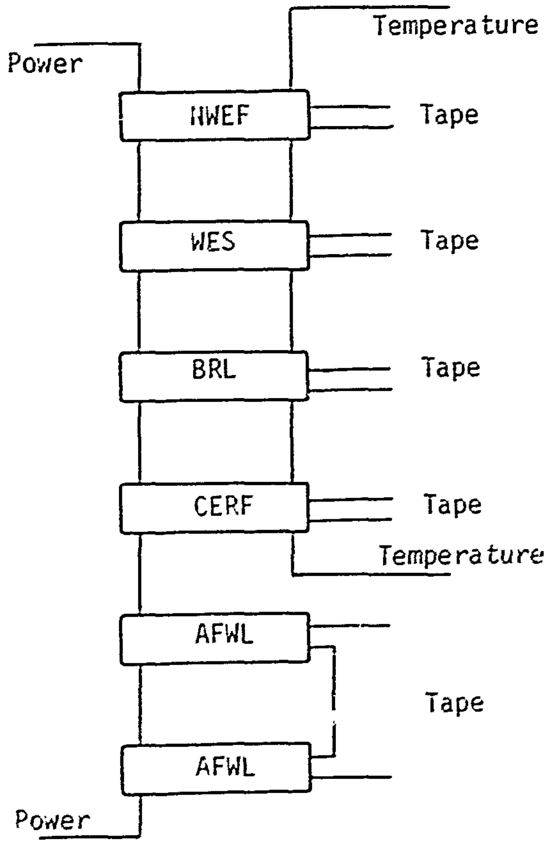


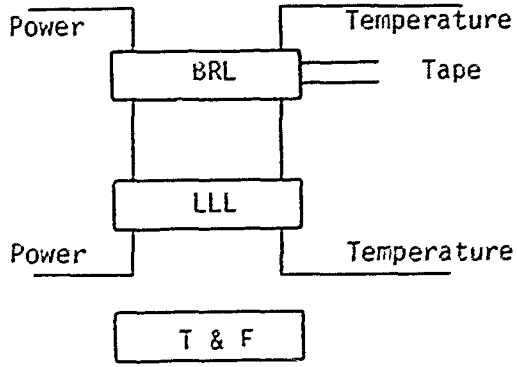
Figure 3-10. Timing and Firing Main Cable Layout

Instrumentation
Park 1



1. All six trailers were monitored in series for power.
2. NWEF, WES, BRL, and CERF were monitored in series for temperature.
3. The AFWL trailers were monitored in series for Recorder run/record. All others were individually monitored.

Instrumentation
Park 2

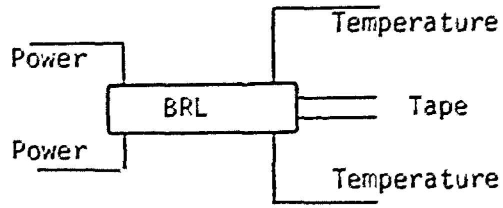


1. BRL and LLL were monitored in series for Temperature.
2. BRL and LLL were monitored in series for Power.
3. BRL was monitored for Tape Recorder run/record.

Bunker

1. ARMCOM Bunker Tape Recorder run/record monitor only.

Instrumentation
Park 3



1. Temperature, Power, and Tape Recorder run/record were each monitored separately.

Figure 3-11. Instrumentation Trailer Monitoring Block Diagram for DICE THROW

Agency	DTI Zero	IRIG A	IRIG B
DRI-1	[illegible]	[illegible]	[illegible]
DRI-2	[illegible]	[illegible]	[illegible]
DRI-3	[illegible]	[illegible]	[illegible]
DRI-4	[illegible]	[illegible]	[illegible]
DRI-C3	[illegible]	[illegible]	[illegible]
DRI-WX	[illegible]	[illegible]	[illegible]
DRI-HELO	[illegible]	[illegible]	[illegible]
DRI-[illegible]	[illegible]	[illegible]	[illegible]
DRI-LF	[illegible]	[illegible]	[illegible]
DRI-[illegible]	[illegible]	[illegible]	[illegible]
DRI-[illegible]	[illegible]	[illegible]	[illegible]
SPI	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
LF, BRL-[illegible]	[illegible]	[illegible]	[illegible]
UK [illegible]	[illegible]	[illegible]	[illegible]
Sweden-Norway CERF	[illegible]	[illegible]	[illegible]
WEF	[illegible]	[illegible]	[illegible]
BRL-HELO	[illegible]	[illegible]	[illegible]
DRES	[illegible]	[illegible]	[illegible]
WES	[illegible]	[illegible]	[illegible]
AFWL	[illegible]	[illegible]	[illegible]
BRL-TF1	[illegible]	[illegible]	[illegible]
BRL-TP2	[illegible]	[illegible]	[illegible]
BRL-TP3	[illegible]	[illegible]	[illegible]

Figure 3-12. Timing Signals Required by Each Agency on DICE THROW

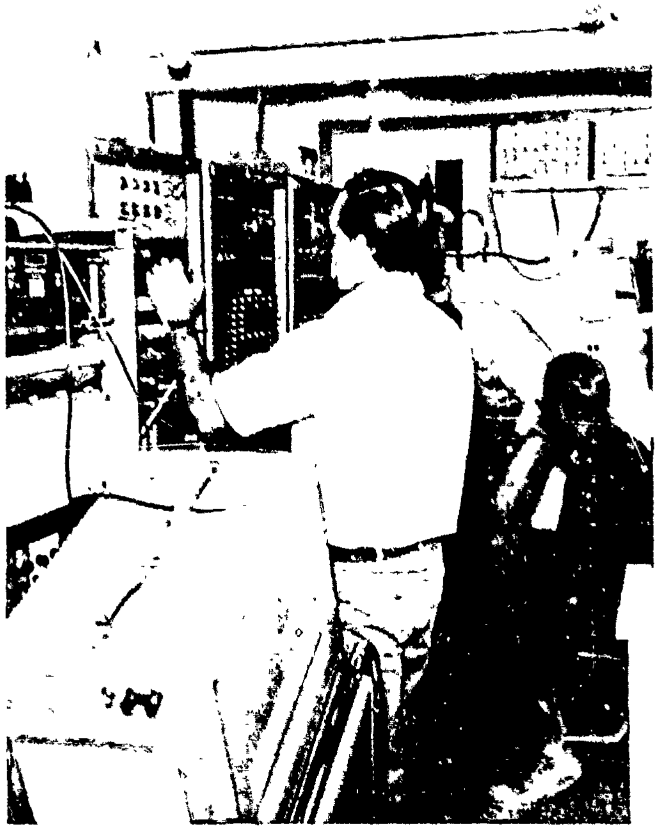


Figure 3-13. Interior of DRES T & F Bunker During Dry-Run (Top Photo), Installation and Checkout of T & F Junction Box Used (Bottom Photo), DICE THROW

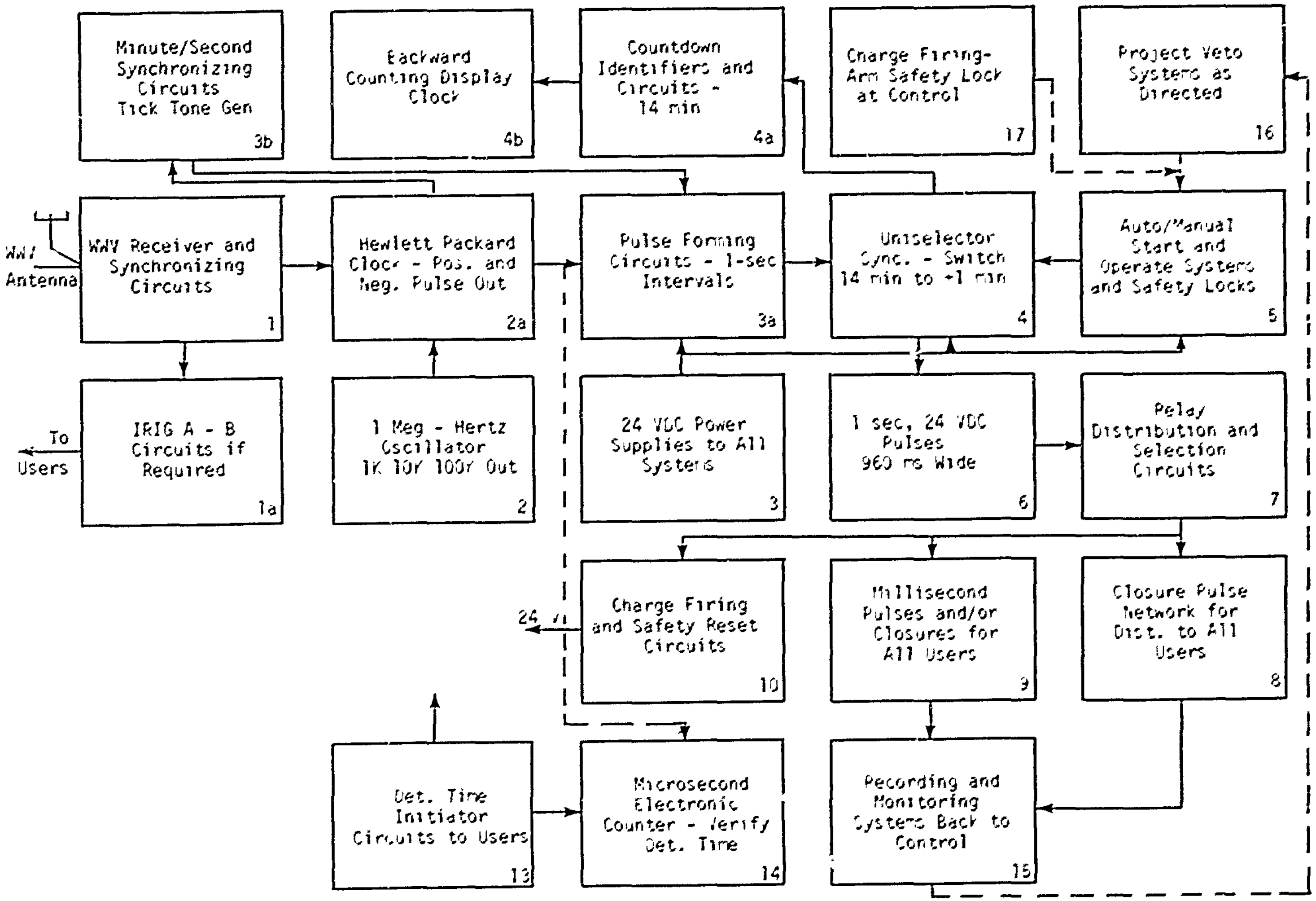


Figure 3-14. Block Diagram—DRES Console for Timing and Firing

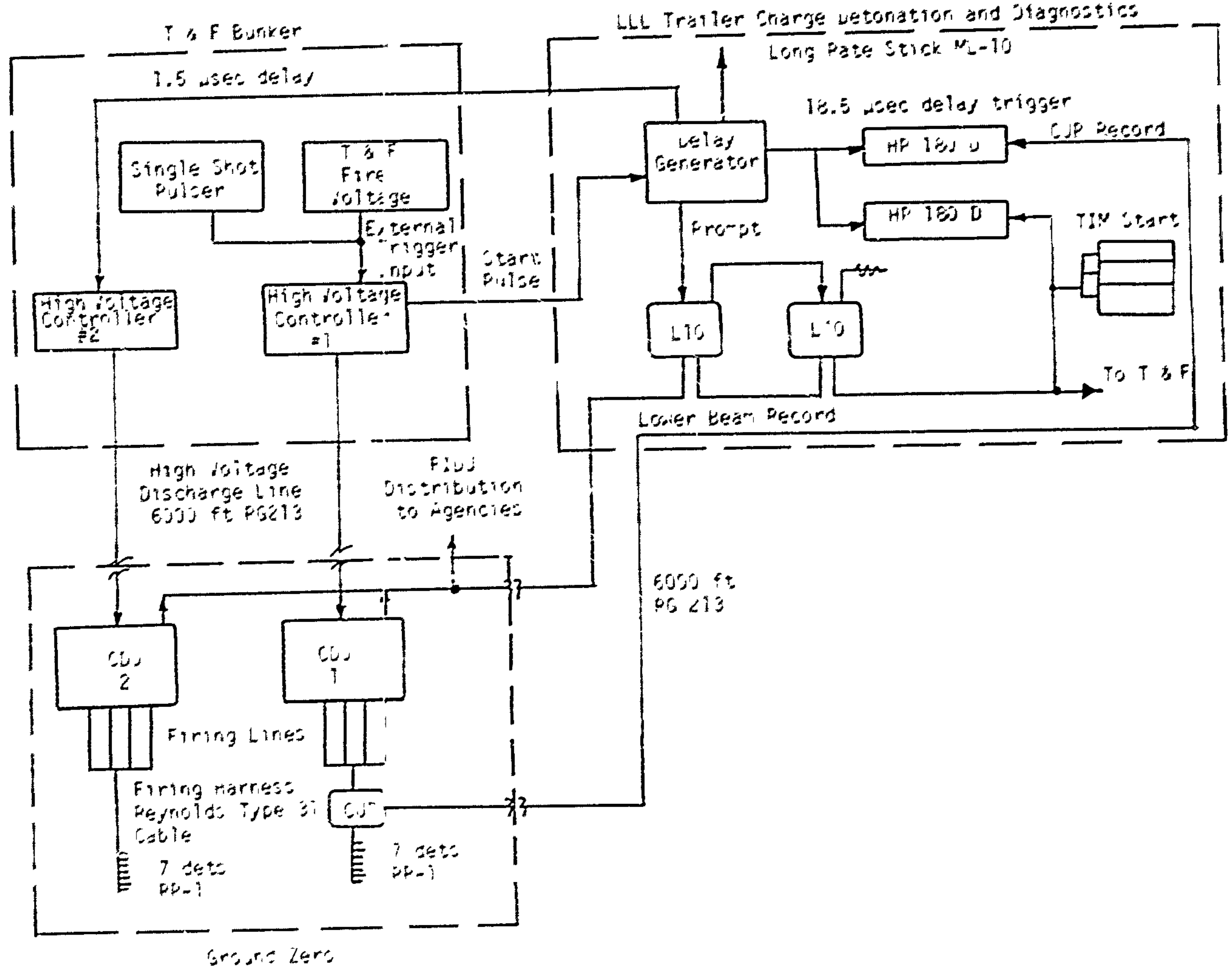


Figure 3-15. Block Diagram of Firing System Used for DICE THROW

simultaneity of the seven octal booster detonations by determining the shock-arrival time at the booster-ANFO interface, obtaining a detonation velocity for the ANFO, measuring detonation-wave transit time and providing pressure profiles within the charge. These additional items are considered as experimentation and will be included in a later section of this report.

LLL designed, built and provided to DNA two certified firing sets to be used on DICE THROW. These sets were thoroughly tested at the site and a determination made to use both firing sets in parallel, firing two series sets (7 each) of detonators (RP 1's).

The firing system comprised four main elements: a high-voltage controller with trigger generator, a 6000-ft (1829-m) transmission line duplexed for charging and firing, a capacitor discharge unit (CDU) and firing lines and harness to initiate seven detonators in a series string. A duplicate back-up system to provide redundancy was triggered 1.5 μsec after the primary system.

The charging of the main energy storage capacitors (located near ground zero) started two minutes before zero-time via the controllers which were located in the Timing-and-Firing Bunker. At zero-time, a fire signal was delivered to the high-voltage controllers, these in turn generated and transmitted firing pulses to the CDU's over separate lines. An additional pulse was also generated and sent to the LLL trailer to trigger a delay generator (required for the charge-detonation diagnostics and for the 1.5 μsec delayed pulse triggering the redundant High-Voltage Controller).

The output from the CDU's fed four parallel firing lines terminating at the firing harness. A reduced and differentiated output from each CDU was mixed and their output used as a fiducial signal for the experimenters. A single-current viewing resistor (CVR) located between the firing lines and the firing harness indicated the rate of rise of current in the detonator-string bridge wires, the time to bridge-wire burst and the peak-burst current.

TRAILER PARK LAYOUT, COMMUNICATIONS, POWER DISTRIBUTION AND CABLING

Trailer Park Layout

Three instrumentation trailer parks were required on the DICE THROW event, each located approximately 6000 ft (1829 m) from ground zero at the ends of the main gage lines. They were layed out according to the instrumentation requirements of the experimenters with the majority of the trailers located in trailer park number one (TP-1). Refer to Figure 3-16 for details pertaining to trailer orientation and agency location. Bendix had shop vans located in TP-1 and -2 and provided maintenance support for all DNA electronic equipment used on DICE THROW by the experimenters. Seven of the instrumentation trailers were DNA property. Office space and additional shop facilities were provided the agencies and were located at the Administration Trailer Park (ADMIN AREA). The FCDNA and WSMR staff also had their office facilities in this area (refer to the photograph in Figure 3-17).

The two AFWL instrumentation vans in TP-1 were bermed (wood bracing and earth fill) to provide protection from the shock wave. A special shock absorber system was placed on the front end (toward ground zero) of a selected number of instrumentation trailers for testing purposes, with the results to be compared with the unprotected vans. The vans with this protection were: WES and BRL in TP-1, BRL and LLL in TP-2, and BRL in TP-3.

The trailer parks were constructed with dirt and a 4-in. (10.2-cm) gravel surface. Instrumentation grounding pits were built in TP-1 and -2; however, only the one in TP-2 was used. Noise problems showing up in TP-1 necessitated a grounding well to be drilled to a depth of approximately 200 ft (61 m). Copper pipe was inserted to the full deptn and all instrumentation grounds were attached to the pipe. TP-3 had a 12-ft (3.7-m) copper rod ground. Lightning arresters with separate grounds were also located in each park. The trailer parks were connected via graveled roads as shown in Figure 3-2. The gravel used for the trailer parks and roads was quarried and crushed on the WSMR and delivered to the site area by a sub-contracted trucking firm.

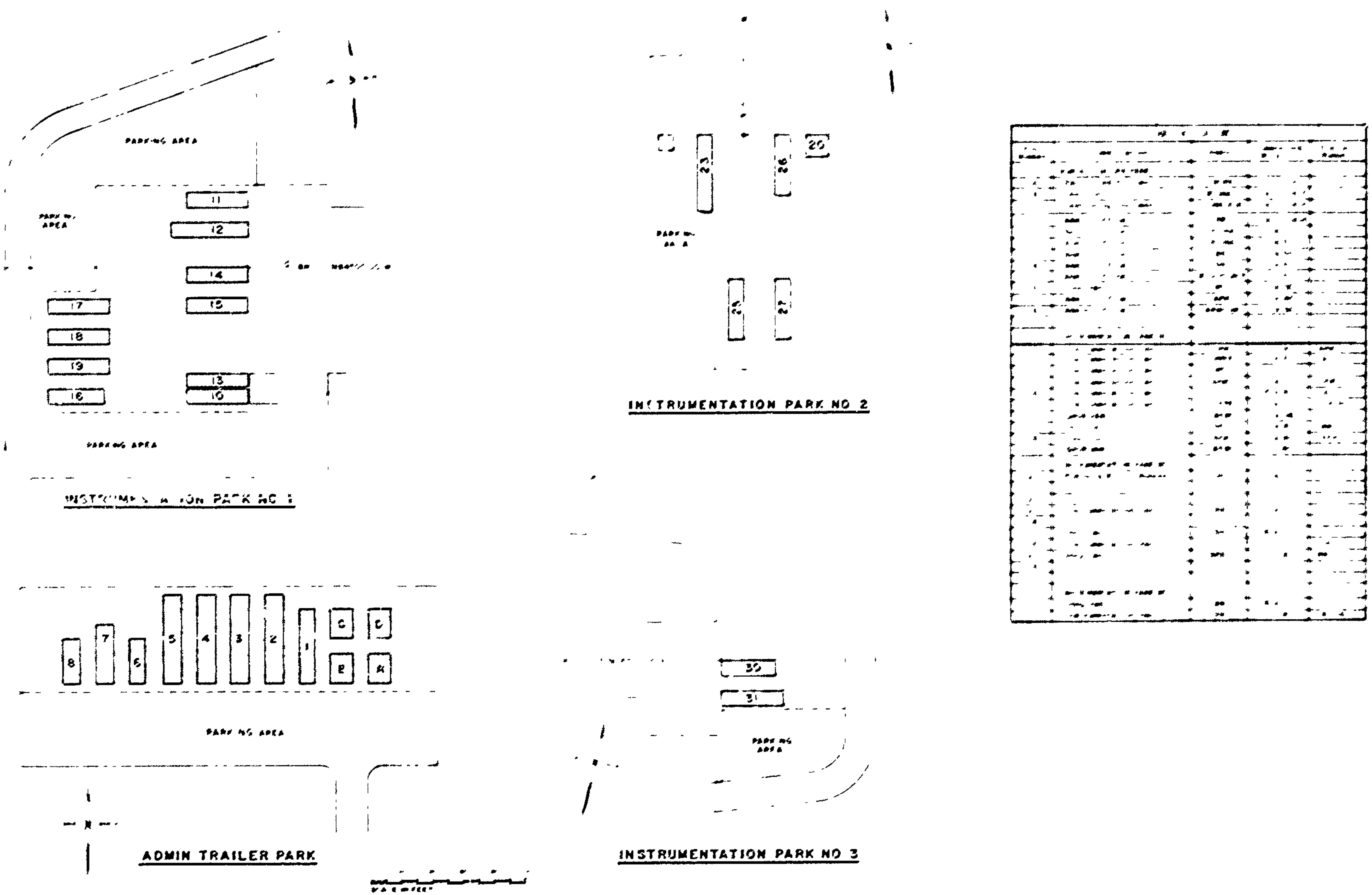


Figure 3-16. Trailer Park Layout and Agency Designation on DICE THROW

Figure 3-17. Photo of ADMIN AREA For DICE THROW

Communications

The types and quantities of communication gear were extensive and varied. They included: 20 telephone lines with 6 extensions, 2 Motorola base stations with 35 G. E. Porta Mobile units, 33 intercom units, and others.

Most of the phone lines were located in the ADMIN AREA office and shop trailers. An emergency phone was located in each of the trailer parks and two lines were required by SRI, one at North Oscura Peak and the other at their receiver station.

The intercom units were placed in office trailers, instrumentation vans and shop trailers and were used exclusively for intra-office communications. The portable radios were used for direct communications between test control and personnel in the test area. The frequency used for these transmissions was 166.0 MHz.

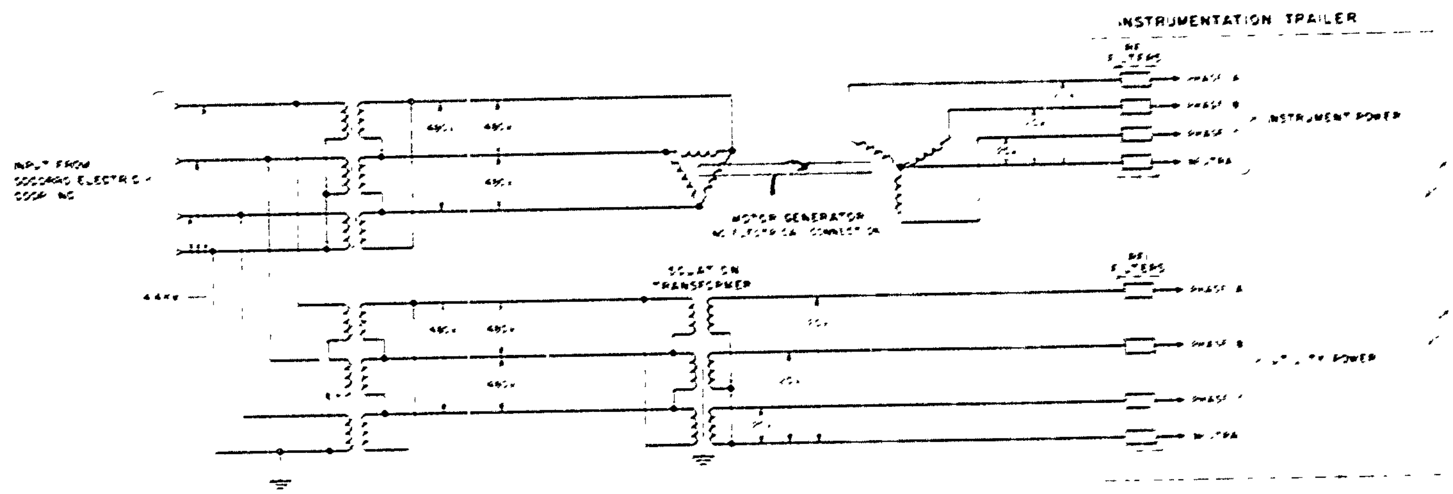
Fifteen frequencies were set aside for use by CCC experiment, nine for SRI, seven for aircraft operations, one for range control and one for artillery support. Refer to Appendix B for further detail.

Power Distribution

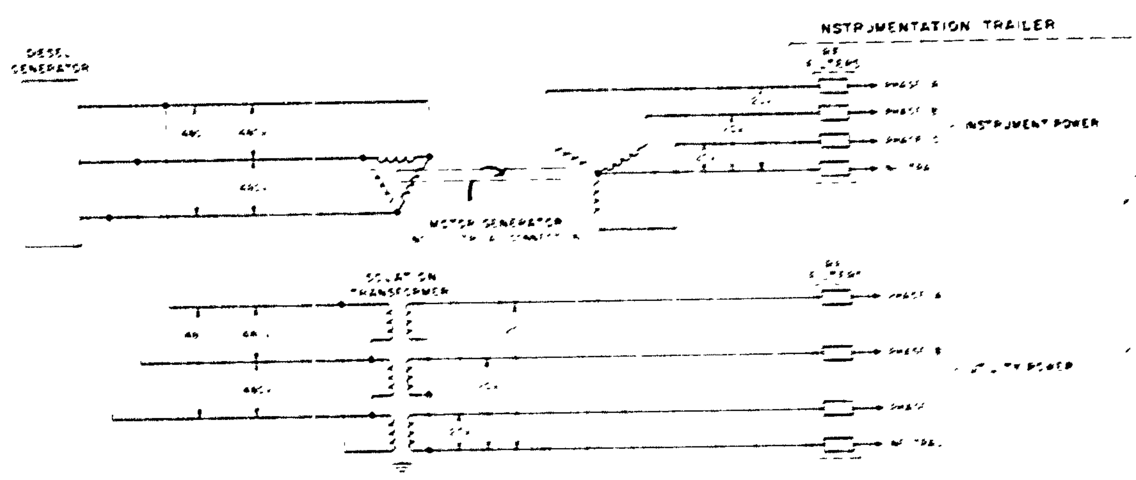
The main source of power for the DICE THROW program was provided by the Socorro Power and Electric Coop., Inc. This commercial power was used exclusively in TP-1 and TP-2 and ADMIN AREA. Additional power requirements were provided by diesel generators. Refer to Figure 3-18 for a typical power distribution schematic, and Figure 3-19 and Table 3-6 for the overall system. Ken O'Brien and Associates (KOA) directed by Mr. D. Cronk under the supervision of Field Command staff provided engineering and drafting support of the DICE THROW program. The services included: power requirements and distribution, run-off protection and finished as-built drawings.

The commercial power was 14.4 kV, three phase, with an expected demand requirement of 1400 kW. This voltage was stepped down and isolated via pole transformers using a wye to delta configuration to 480 volts. Three areas in the test bed required substations due to their power demand and remote locations. In these cases, the 480-volt source was stepped up to 4160 volts for transmission purposes, then reduced to 480 volts at the substation for distribution to the ARMCOM bunker, DRI-2 (main camera station) and the AFWL stations. The ARMCOM bunker demand was supplied by the diesel generator system located in TP-3 as was the DRI-4 location. During the initial fielding stages, the ADMIN AREA was powered by the diesel generator system which was later moved to TP-3 (two at 125 kW, only one used at a time). Additional generators were used to power the DRES station (30 kW) and DRI-3 remote camera station (100 kW). The DRES station was originally supplied commercial power; however, a lightning strike degraded the power cable to the extent that prohibited its use.

The instrumentation trailers required both utility and instrument power. Refer to Figures 3-20, 3-21 and 3-22 for details of power distribution in the trailer park areas. This was accomplished by using motor generator sets that were run from commercial or diesel generator systems, the motor generator sets (placed on the instrumentation side) providing the isolation necessary between the two types of demand. The AFWL instrumentation vans in TP-1 did not use this isolation technique, and this created a problem during one of the dry runs. One of the air-conditioning units (two in each van) in



TYPICAL COMMERCIAL POWER ELECTRICAL SYSTEM



TYPICAL DIESEL POWERED ELECTRICAL SYSTEM

Figure 3-18. Typical Power Distribution Schematic Used on DICE THROW

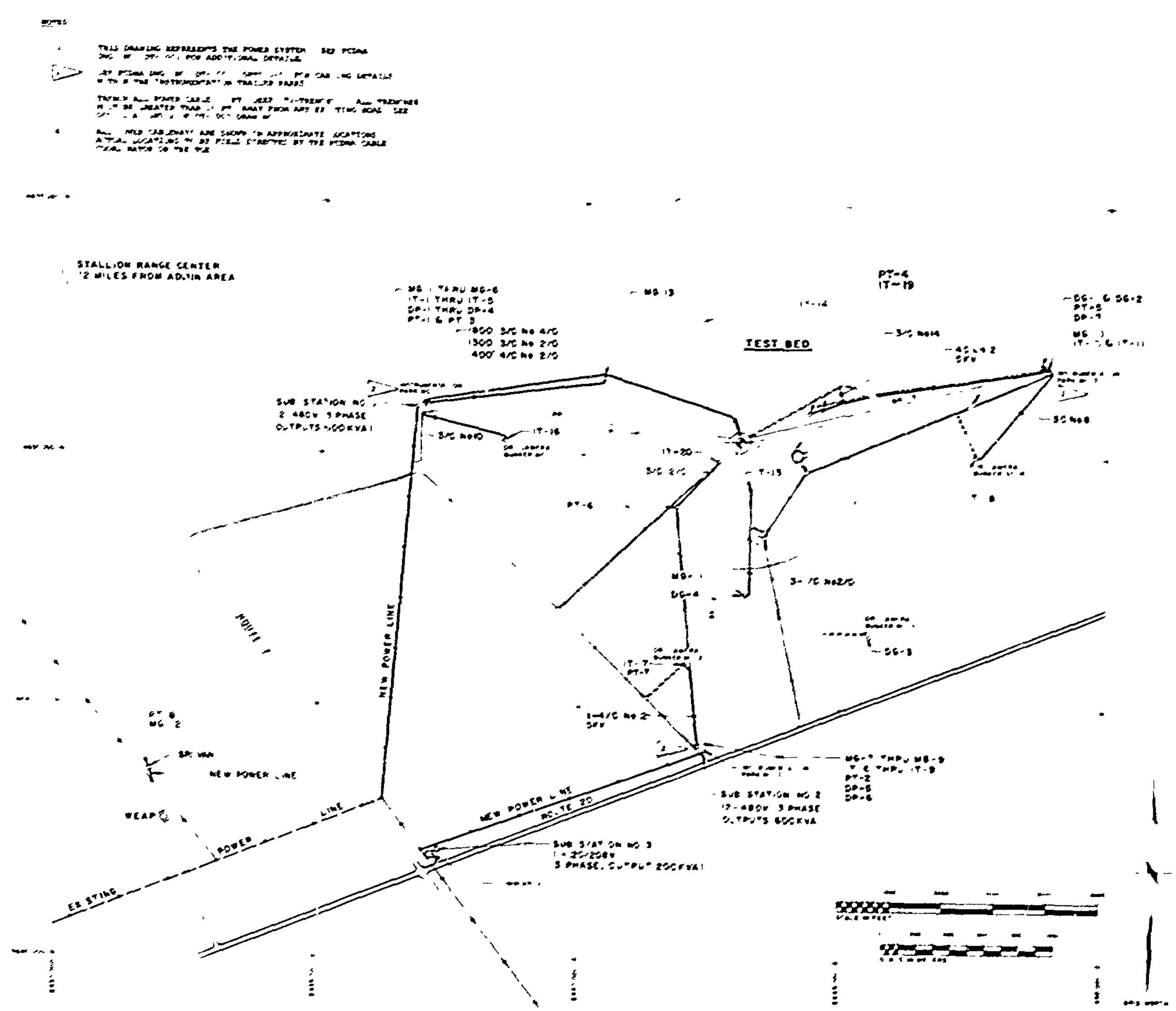


Figure 3-19. Power Cable Layout on DICE THROW

Table 3-6. Power Distribution Legend, DICE THROW

POWER REQUIREMENTS			
Ref. No.	Required For	Required Power (in KW)	Power Provided (in KW)
MOTOR GENERATORS:			
MG- 1	NWEF INST. TRAILER 40002	30	50
2	WES INSTR. TRAILER 50021	30	50
3	BRL INSTR. TRAILER 40003	20	30
4	CERF INST. TRAILER 36040	30	50
5	AFWL INST. TRAILER AFWL-05	40	50
6	AFWL INST. TRAILER AFWL-07	40	50
7	BRL INSTR. TRAILER 50025	50	50
8	LLL INSTR. TRAILER 36016	30	50
9	DRES T&F BUNKER	30	50
10	BRL INSTR. TRAILER 40006	30	50
11	DRES INST. BUNKER	20	30
12	SRI VAN	30	30
13	BRL HELO BUNKER	20	30
ISOLATION TRANSFORMERS:			
IT- 1	NWEF INST. TRAILER 40002	30	50
2	WES INSTR. TRAILER 50021	30	
3	BRL INSTR. TRAILER 40003	20	
4	CERF INST. TRAILER 36040	30	
5	AFWL INST. TRAILER AFWL-05	30	
6	BRL SHOP VAN	45	
7	BRL INSTR. TRAILER 50025	30	
8	LLL INSTR. TRAILER 36016	30	
9	BFEC SHOP VAN	20	
10	BRL INSTR. TRAILER 40006	20	
11	BRL SHOP TRAILER	15	
12			
13	DRES CAMERAS	12	

Table 3-6. Power Distribution Legend, DICE THROW (Continued)

POWER REQUIREMENTS			
Ref. No.	Required For	Required Power (in KW)	Power Provided (in KW)
ISOLATION TRANSFORMERS (Continued):			
IT-14	ARMCOM BUNKER	20	50
15			
16	DRI CAMERA BUNKER #1	4.8	
17	DRI CAMERA BUNKER #2	12	
18	DRI CAMERA BUNKER #4	6	
19	SRI MAIN TRANSMITTER	0.5	
20	AFWL CAMERAS	30	50
DIESEL GENERATORS:			
DG- 1	TRAILER PARK #3 POWER	125	125
2	TRAILER PARK #3 POWER	125	125
3	DRI BUNKER #3	10	15
4	DRES BUNKER	55	100
POWER TRANSFORMERS:			
PT- 1	SHOP VAN POWER (480/208 V)	73	112
2	AFWL & DRI (480/4160	92	300
3	AFWL INSTR. VAN (208/480V)		
4	ARMCOM BUNKER (4160/480 V)	55	300
5	ARMCOM BUNKER (480/4160 V)	55	300
6	AFWL CAMERA (4160/480 V)	30	300
7	DRI #2 (4160/480 V)	12	300
8	SRI INSTR. VAN (120/480 V)		
DISCONNECT PANELS:			
DP- 1	UTILITY TP #1 (SOUTH)		
2	INSTRUMENT TP #1 (SOUTH)		
3	UTILITY TP #1 (NORTH)		
4	INSTRUMENT TP #1 (NORTH)		
5	UTILITY TP #2		
6	INSTRUMENT TP #2		
7	POWER TP #3		

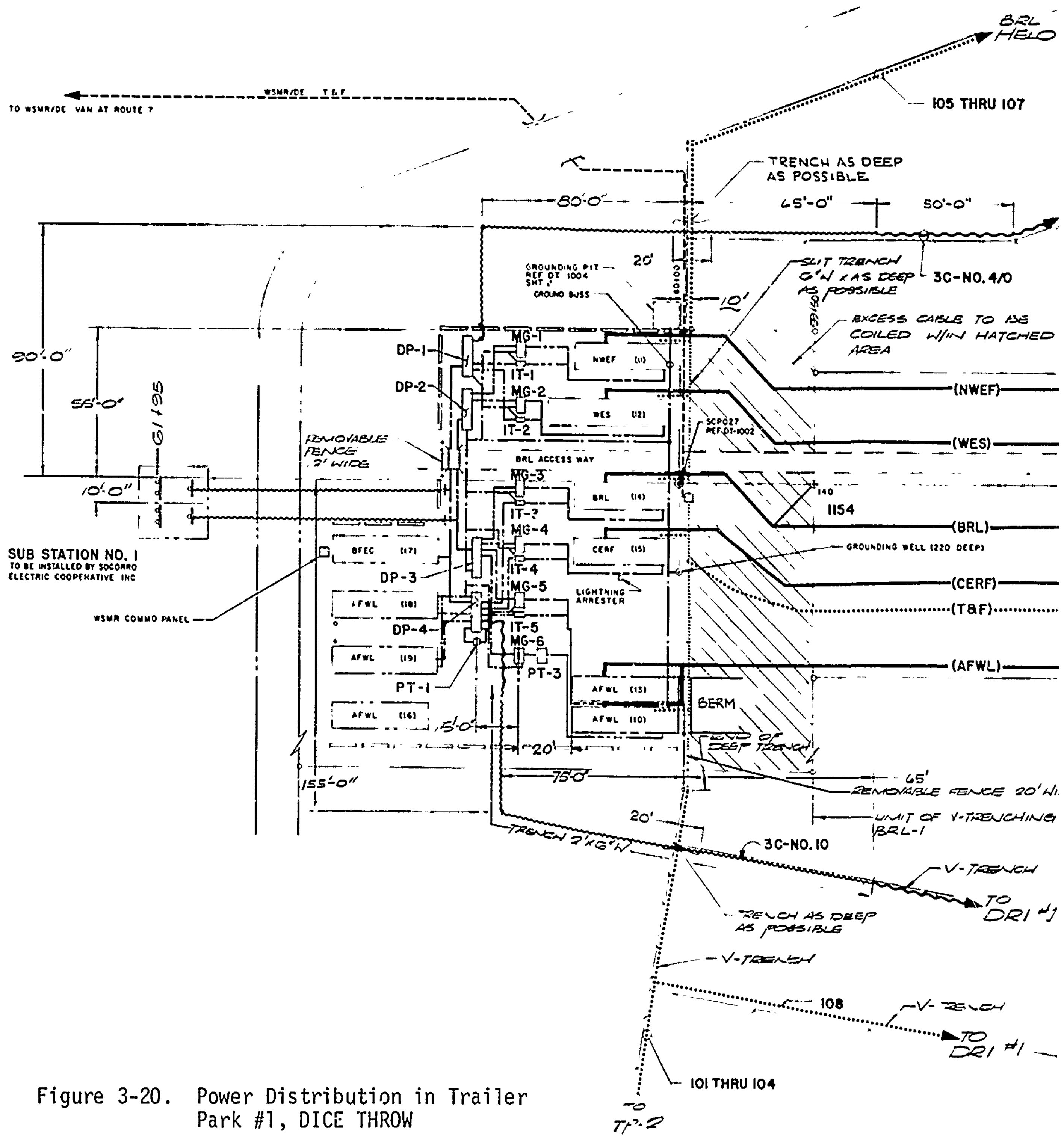
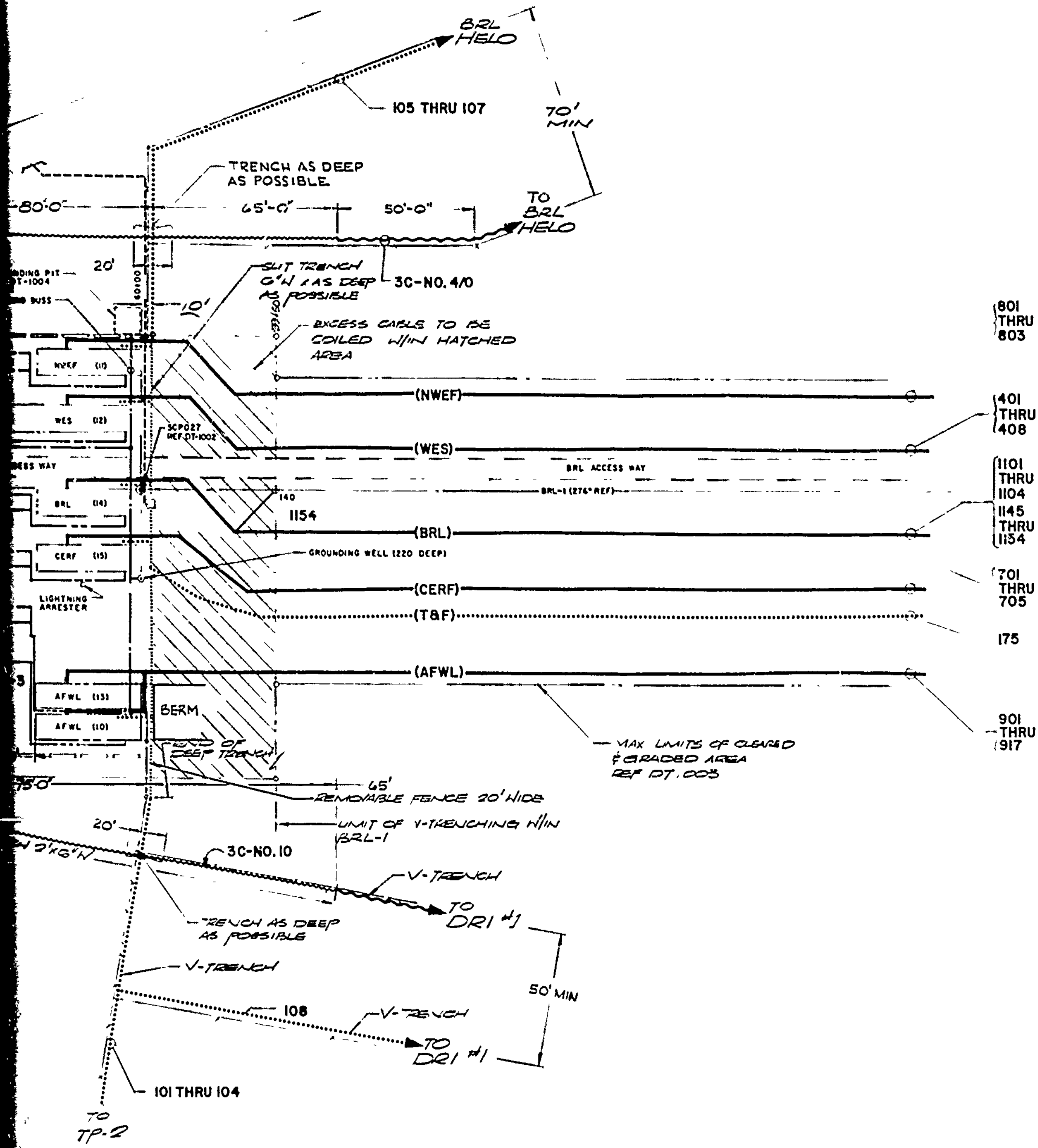


Figure 3-20. Power Distribution in Trailer Park #1, DICE THROW



BRL HELO
105 THRU 107
70' MIN
TRENCH AS DEEP AS POSSIBLE
80'-0"
65'-0"
50'-0"
TO BRL HELO
20'
SLIT TRENCH 6"W & AS DEEP AS POSSIBLE
3C-NO. 4/0
10'
EXCESS CABLE TO BE COILED W/IN HATCHED AREA
801 THRU 803
NWEF (11)
(NWEF)
WES (12)
SCP027 REF.DT-1002
(WES)
401 THRU 408
BRL ACCESS WAY
BRL-1 (276" REF)
BRL (14)
140
1154
(BRL)
1101 THRU 1104
1145 THRU 1154
CERF (15)
GROUNDING WELL (220 DEEP)
(CERF)
701 THRU 705
LIGHTNING ARRESTER
(T&F)
175
(AFWL)
AFWL (13)
AFWL (10)
BERM
END OF DEEP TRENCH
901 THRU 917
MAX LIMITS OF CLEARED & GRADED AREA REF DT.003
75'-0"
65'
REMOVABLE FENCE 20' WIDE
20'
LIMIT OF V-TRENCHING W/IN BRL-1
3C-NO.10
V-TRENCH
TO DRI #1
TRENCH AS DEEP AS POSSIBLE
V-TRENCH
50' MIN
108
V-TRENCH
TO DRI #1
101 THRU 104
TO TP-2

2

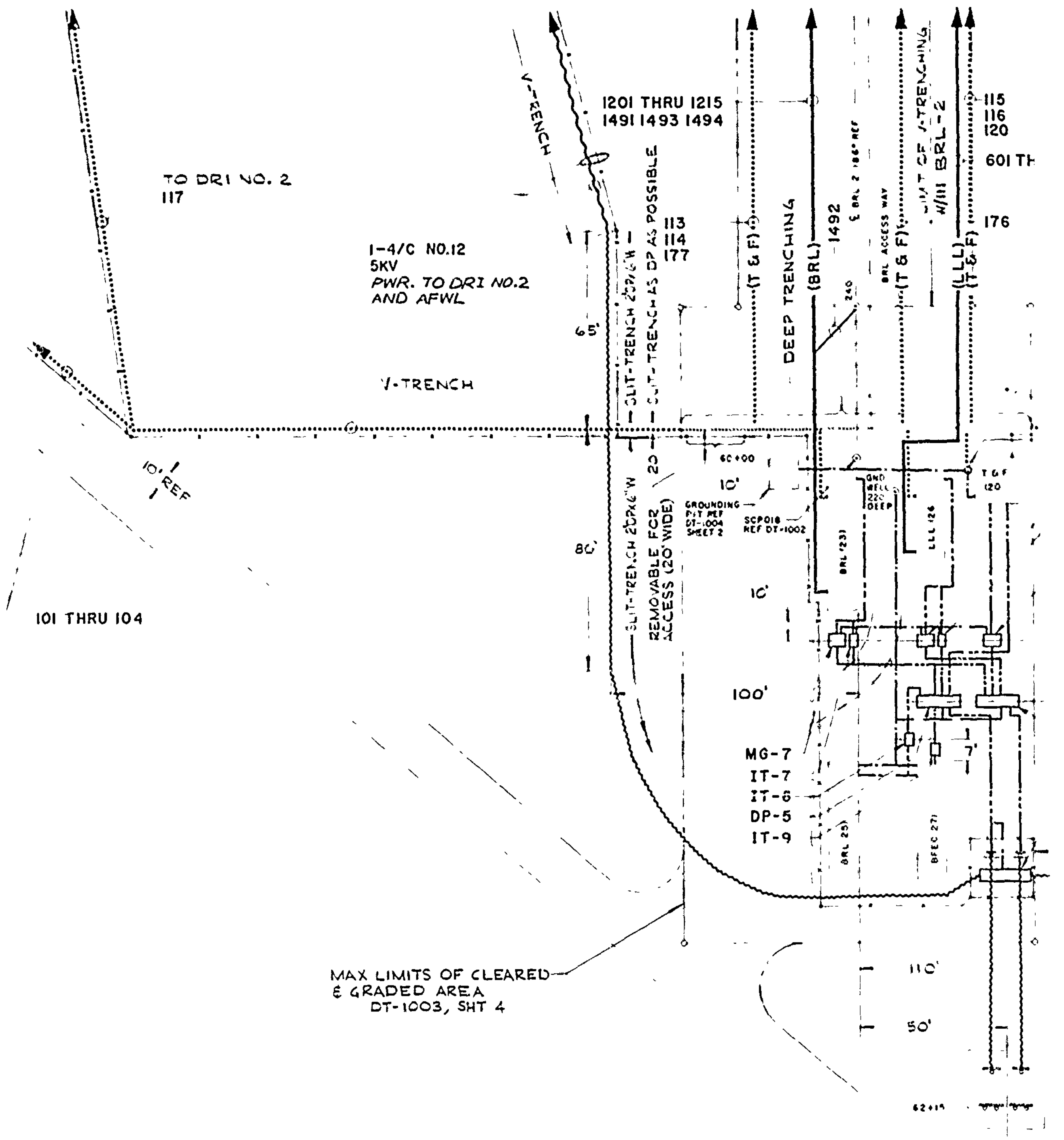
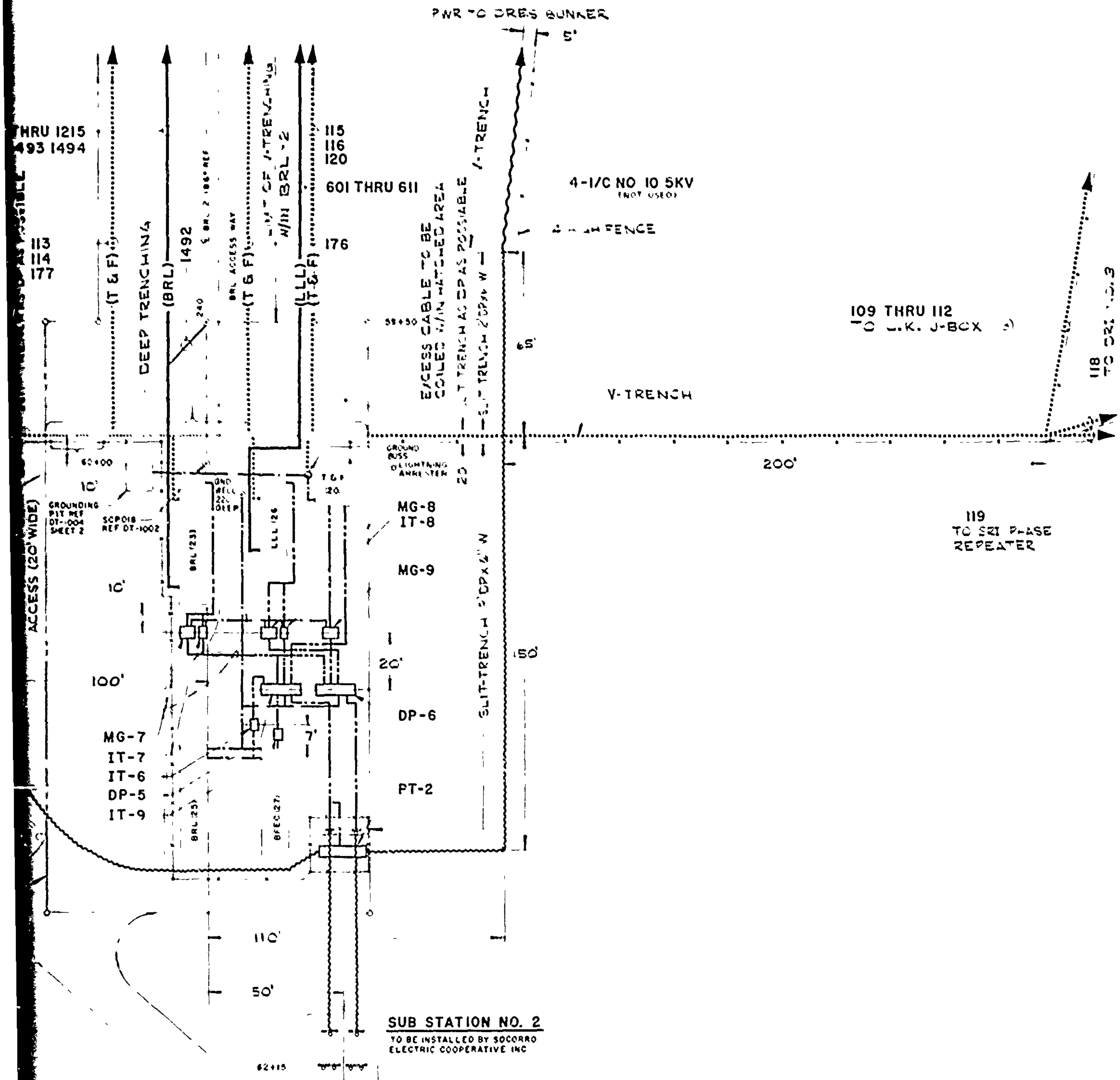


Figure 3-21. Power Distribution in Trailer Park #2, DICE THROW



k #2, DICE THROW

2

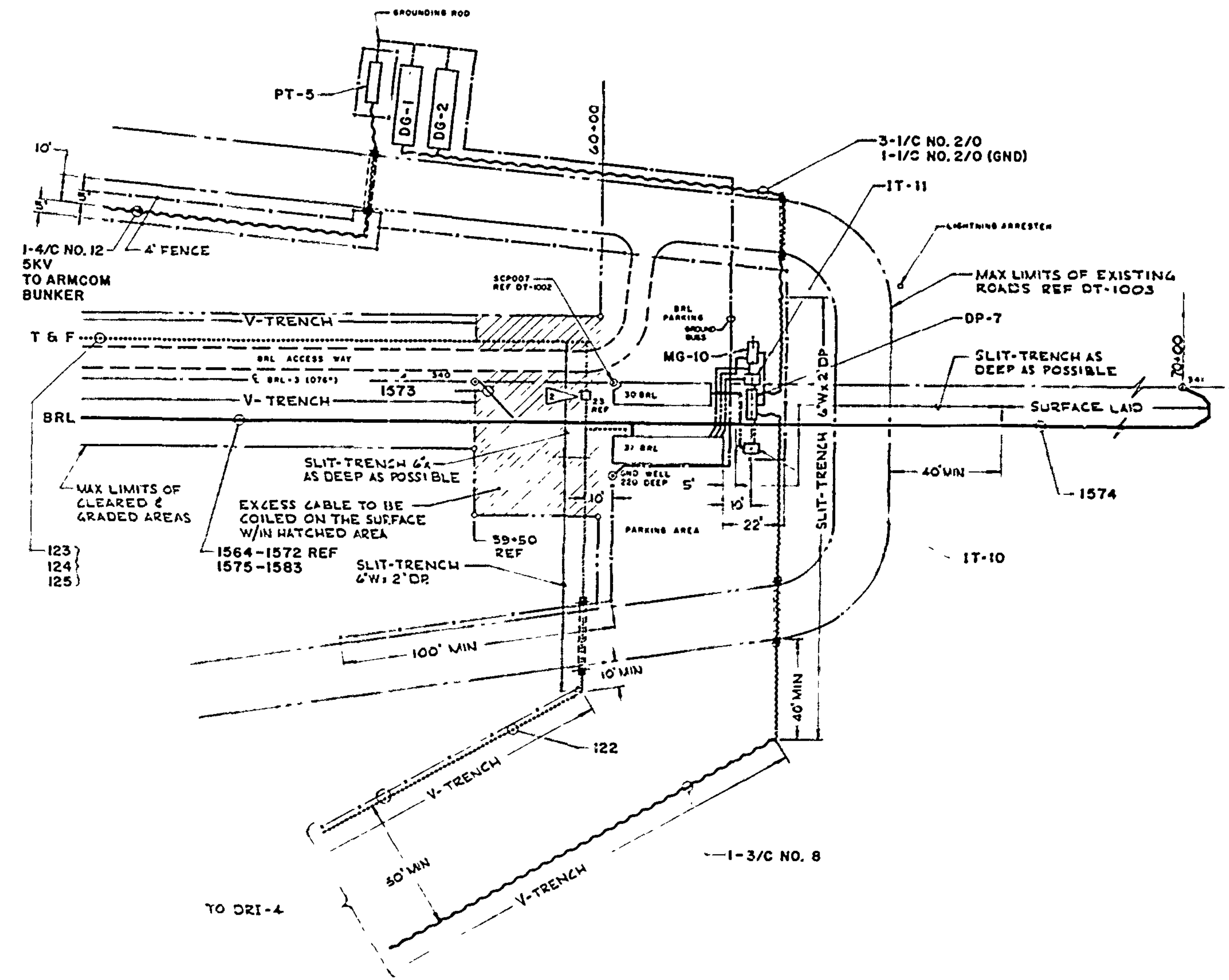


Figure 3-22. Power Distribution in Trailer Park #3, DICE THROW

one of the trailers froze up. When switching between units took place, a voltage spike was produced causing an overvoltage condition to be indicated on the voltage monitoring equipment. This was a difficult problem to locate since all six instrumentation trailers in TP-1 were in series for power monitoring.

Cabling

Twenty-one types of cable were used for the instrumentation and power requirements on DICE THROW (refer to Table 3-7). Mr. Bob Ward of EG&G Las Vegas provided the cable coordination between DNA and the experimenters. Almost 1.5 million ft (457 km) of cable was layed out, 33,450 ft (10.20 km) of power cable and 1,453,964 ft (443.2 km) of instrumentation cable. After the event, the cable recovery amounted to: all power cable and 393,300 ft (119.9 km) of main instrumentation cable.

EXPERIMENT DESCRIPTIONS

1. AFTAC, Patrick AFB

   PROJECT OFFICER: TSgt T. Cummings, (305) 494-2451

   OBJECTIVE: Record Optical Time-History fireball measurements.

   EXPERIMENT DESCRIPTION: The Super Suitcase Optical (SSO) which measures the optical output versus time for light-producing phenomena and the Super Suitcase EMP (SSE) which measures the "E Field" of the Electromagnetic Pulse versus time for phenomena that produce EMP were fielded at the WEAP site which is 12,700 ft (3,871 m) from GZ (refer to Figure 3-2 for the location of WEAP site). Other equipment fielded included a Hycam High Speed Motion Picture Camera, an Image Converter Streak Camera, and a Microsecond Recording System.

2. Air Force Weapons Laboratory (AFWL)

   TITLE: Blast Effects on Blast Door and Shelter, DNA Project #398

   PROJECT OFFICER: Capt. J. Teague (505) 264-0226

   OBJECTIVES: Obtain experimental data for the development of hardened aircraft shelters by measuring and recording: (1) the loading and dynamic response of a one-third scale,

Table 3-7. Instrumentation and Power Cable Required on DICE THROW

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]

proposed aircraft shelter closure subjected to face-on airblast pressure; (2) the response of a one-third scale TAB VEE shelter arch and a one-third scale upgraded TAB VEE shelter arch when exposed to an airblast environment; (3) the airblast and ground motion effects on a buried surface-flush aircraft shelter. Refer to Figure 3-23 for an overall view of these shelters and Figure 3-24 for the layout drawing.

EXPERIMENT DESCRIPTION:

(a) Upgraded Aircraft Shelter Closure - Shelter "A"

The upgraded one-third scale shelter closure was fabricated by the Civil Engineering Research Facility (CERF) on Kirtland AFB, NM. It was later transported to the test site and erected on the previously constructed foundation slot and adjacent supporting shelter arch which was built at the site by FALCON, Inc. of Socorro, NM (refer to Figure 3-25). This one-third scale model was placed face-on to the blast at a range of 492.13 ft (150 m), the anticipated 65 psi (455 kPa)

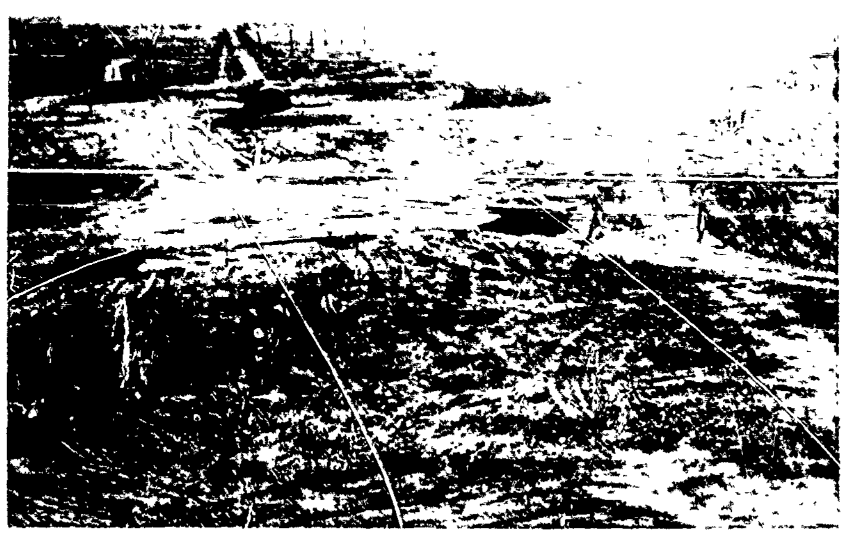


Figure 3-23. Overall View of the AFWL Shelters on DICE THROW

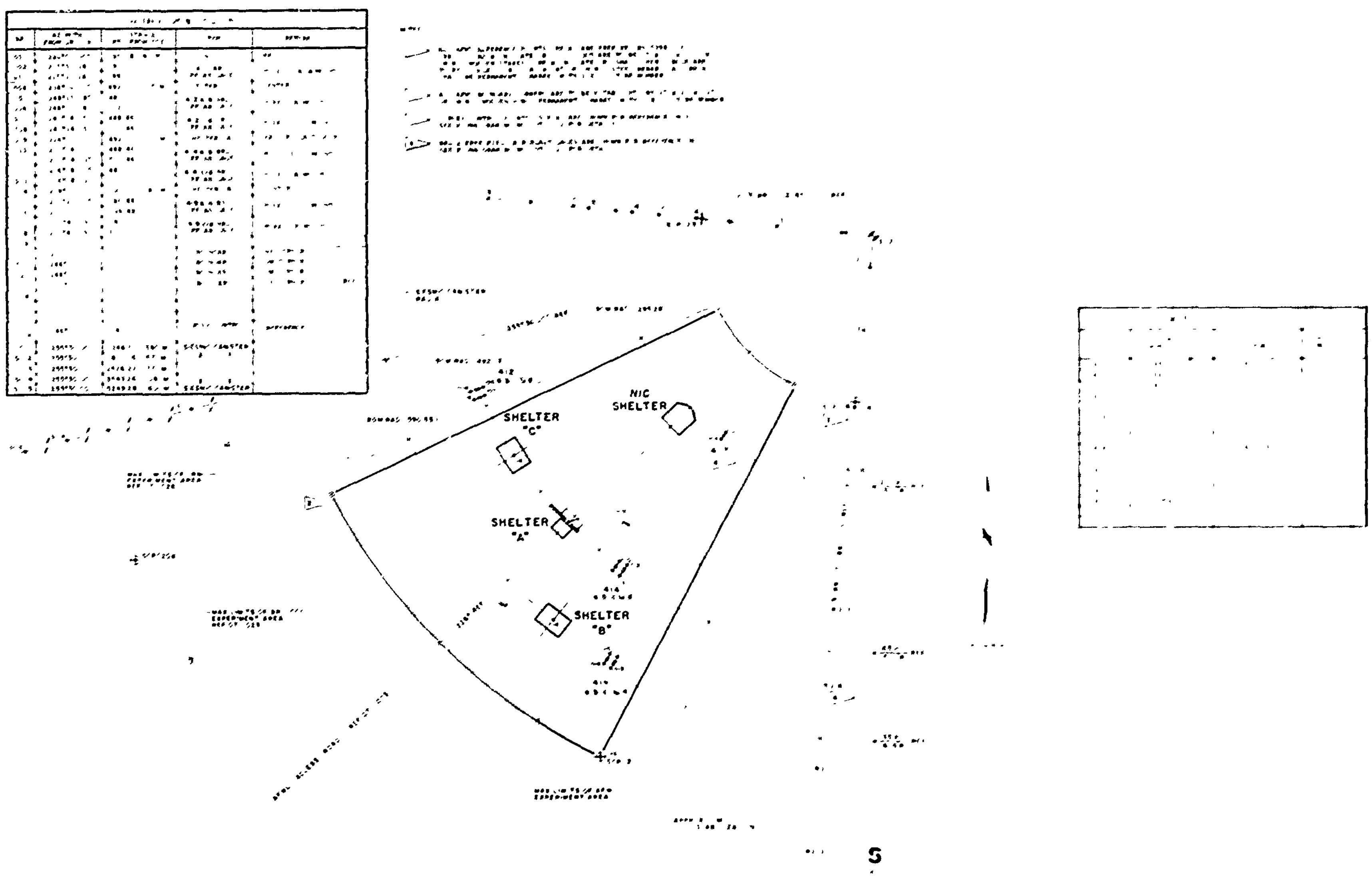
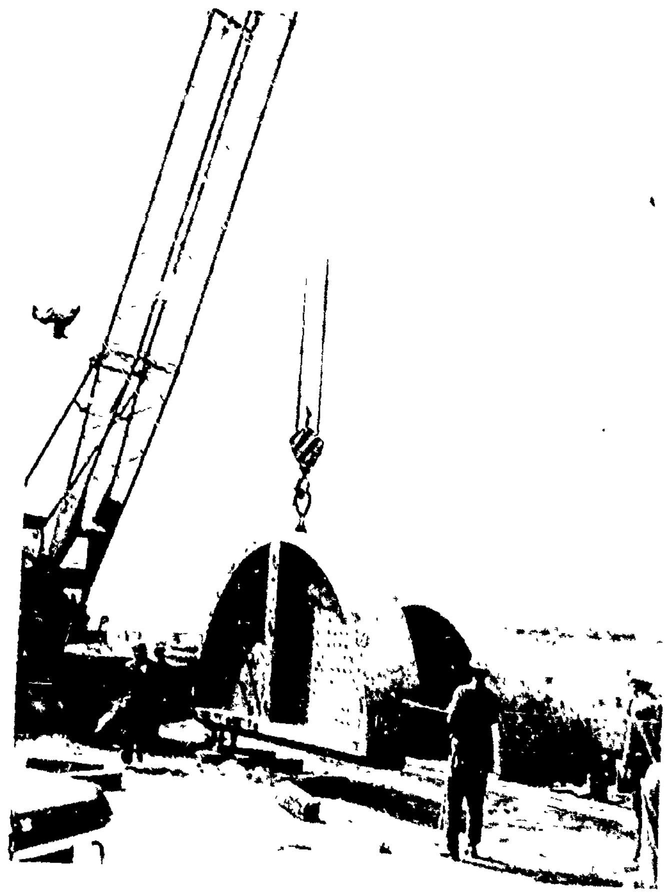


Figure 3-24. Layout of AFWL Shelters on DICE THROW



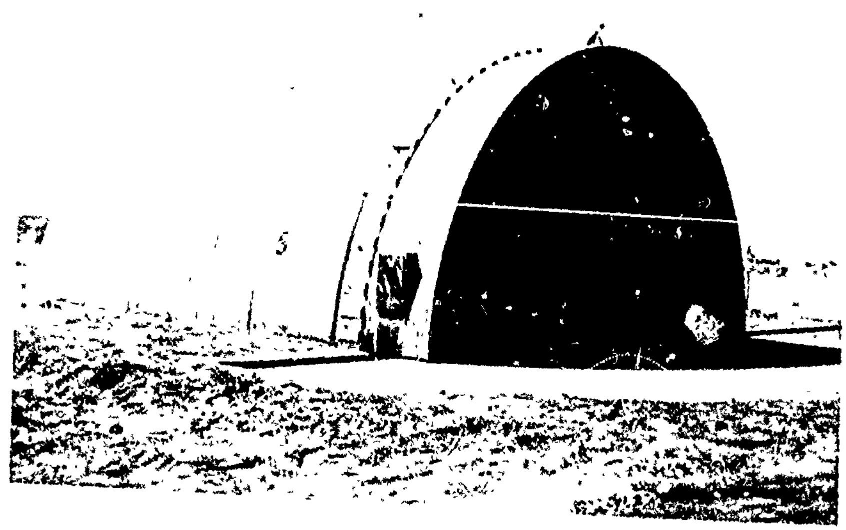


Figure 3-25. The AFWL DICE THROW Upgraded Aircraft Shelter Closure During Installation (Top Photo), and Completed (Bottom Photo)

level. At this range the blast was expected to produce measurable inelastic response of the closure.

Instrumentation for the shelter and closure consisted of 93 active electronic measurements including blast pressures, accelerometers, velocity, displacement and strain gages. Four pressure sensitive gages were also installed in the foundation slot to measure bearing stress transmitted to the foundation slot from the closure.

(b) First Generation (TAB VEE) Shelter Arch - Shelter "B"

The modified one-third scale TAB VEE arch shelter, constructed by FALCON was oriented side-on to the blast at a range of 600 ft (180 m) at the predicted 35-psi (245-kPa) level (refer to Figure 3-26). At this range the blast was expected to produce measurable inelastic response of the arch.

Instrumentation for the shelter consisted of 54 active electronic measurements, including blast pressures, accelerometers, velocity and strain gages.

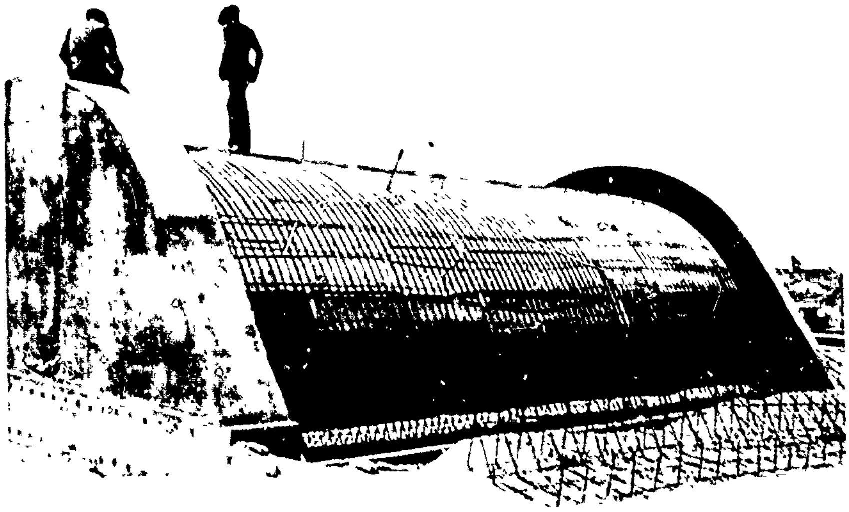
(c) Upgraded First Generation (TAB VEE) Shelter Arch - Shelter "C"

This upgraded one-third scale TAB VEE arch structure was tested, oriented side-on to the blast at a range of approximately 500 ft (150 m), the same pressure level as Shelter "A". This shelter is the same as Shelter "B", but with a heavy overlay of concrete (refer to Figure 3-27).

Instrumentation for the test structure consisted of 74 active electronic measurements, including blast pressures, accelerometers, velocity and strain gages.

(d) Hard Flush Aircraft Shelter - Shelter "D"

This shelter was a one-third scale model of a Boeing designed underground aircraft shelter (refer to Figure 3-28). The shelter was constructed by Bob Rutherford Construction Co., Albuquerque, New Mexico, and buried at a distance of 295.3 feet (90 m) from ground zero, with the top flush with the ground. The shelter was to be exposed to the 270-psi (1890-kPa) incident overpressure level.



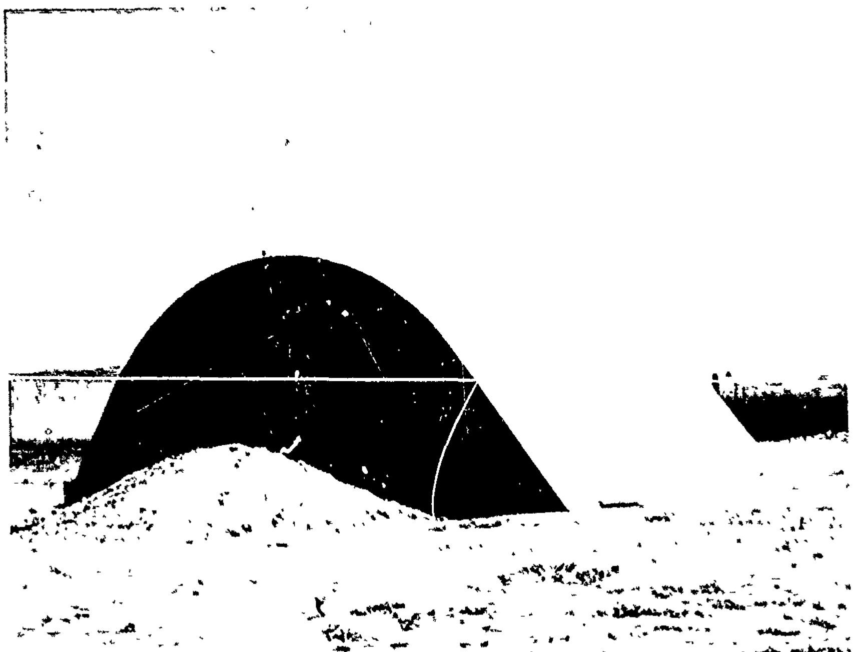
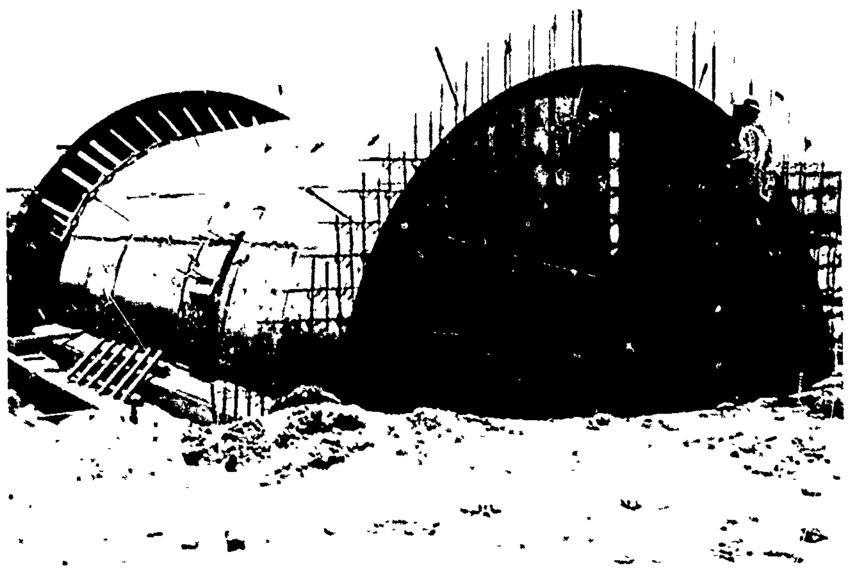


Figure 3-26. The AFWL DICE THROW Modified One-Third Size TAB VEE Arch Shelter During Construction (Top Photo), and Completed (Bottom Photo)



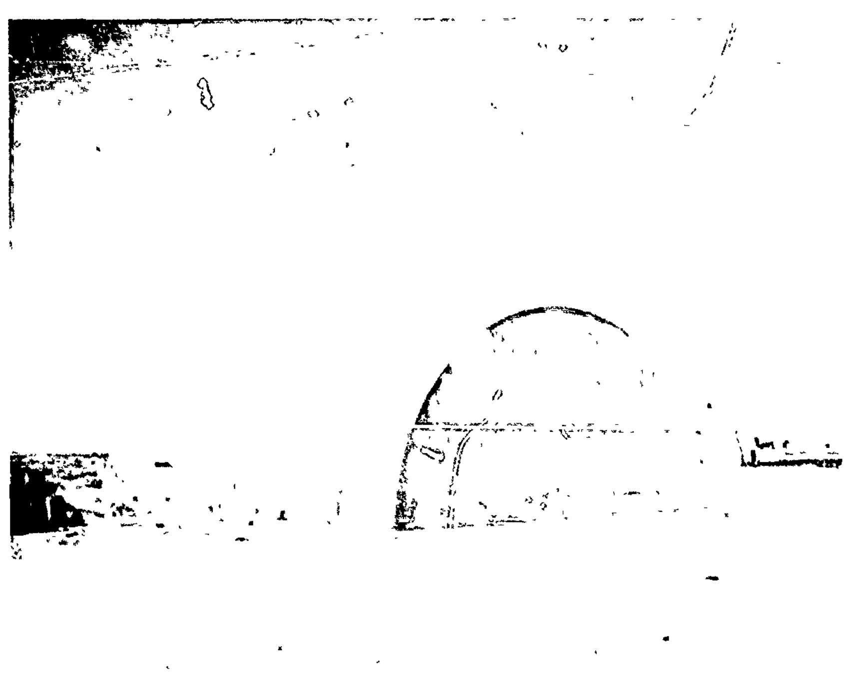
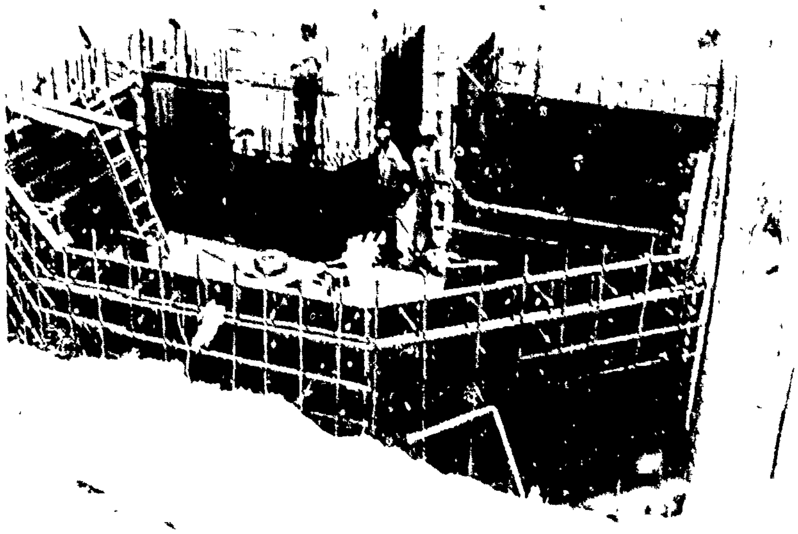


Figure 3-27. AFWL DICE THROW Upgraded First-Generation TAB VEE Shelter Arch During Construction (Top Photo), and Completed (Bottom Photo)



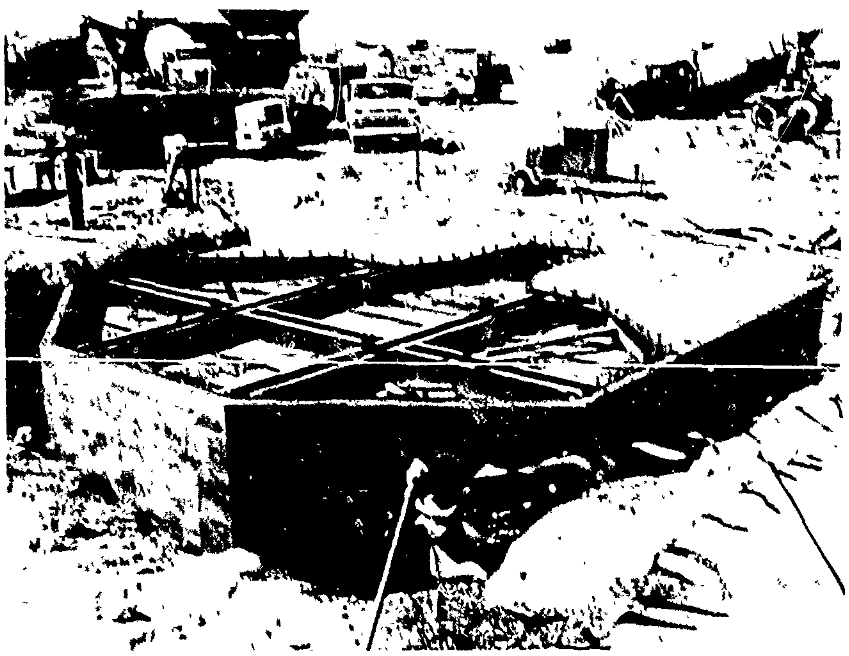


Figure 3-28. AFWL DICE THROW Hard Flush Aircraft Shelter (Boeing Designed), Both Photos During Construction

Instrumentation for the shelter consisted of 76 active electronic measurements, 16 of which were in the free field. The 16 free-field gages were on the centerline of the structures at 9.84 ft (3 m) from either edge of the structure on a radial from ground zero. Other measurements included blast pressures, accelerometers, velocity and strain gages, and interface pressure gages. For further information regarding this experiment description, refer to AFWL-TR-77-001.

3. AFWL/CERF

TITLE: Ejecta Collectors

PROJECT OFFICERS: Mr. G. Jones (CERF) and Dr. R. Henny (AFWL)

OBJECTIVE: Determine permanent near-surface ground displacement and ejecta coverage from the blast. Refer to Figure 3-29 for an overall layout of the experiment.

EXPERIMENT DESCRIPTION: Displacement pins were placed along three radials (15, 105 and 195 degrees) from SGZ. The pins had a 3-ft (.91-m) spacing from 71 ft (21.6 m) to 191 ft (58.2 m) and 10-ft (3.04-m) spacing from 200 ft (61.0 m) to 600 ft (182.9 m). Concrete spheres, bowling balls and aluminum discs were placed at different depths at two radials as shown in Figure 3-30. Figure 3-31 shows the two radials (0 and and 145 degrees) used for the artificial missile placement. Details pertaining to the layout of surface plates, pits and walls are shown in Figure 3-32.

4. AFWL/ERIM/SMU

TITLE: Seismic Measurements

PROJECT OFFICERS: Mr. S. Melzer (AFWL) (505) 264-0482, and Capt. A. Scheinker (AFWL)/Mr. R. Turpening (ERIM)/Dr. G. Herrin (SMU).

OBJECTIVE: Document the nature of the far-field ground-motion environment in the DICE THROW alluvial geologic situation.

EXPERIMENT DESCRIPTION: The AFWL, ERIM and SMU participated in seismic monitoring during DICE THROW. The AFWL had five stations located west-southwest of GZ out to a range of 5250 ft (1600 m). These stations were multiplexed prior to transmission via cable to the instrumentation van. SMU had

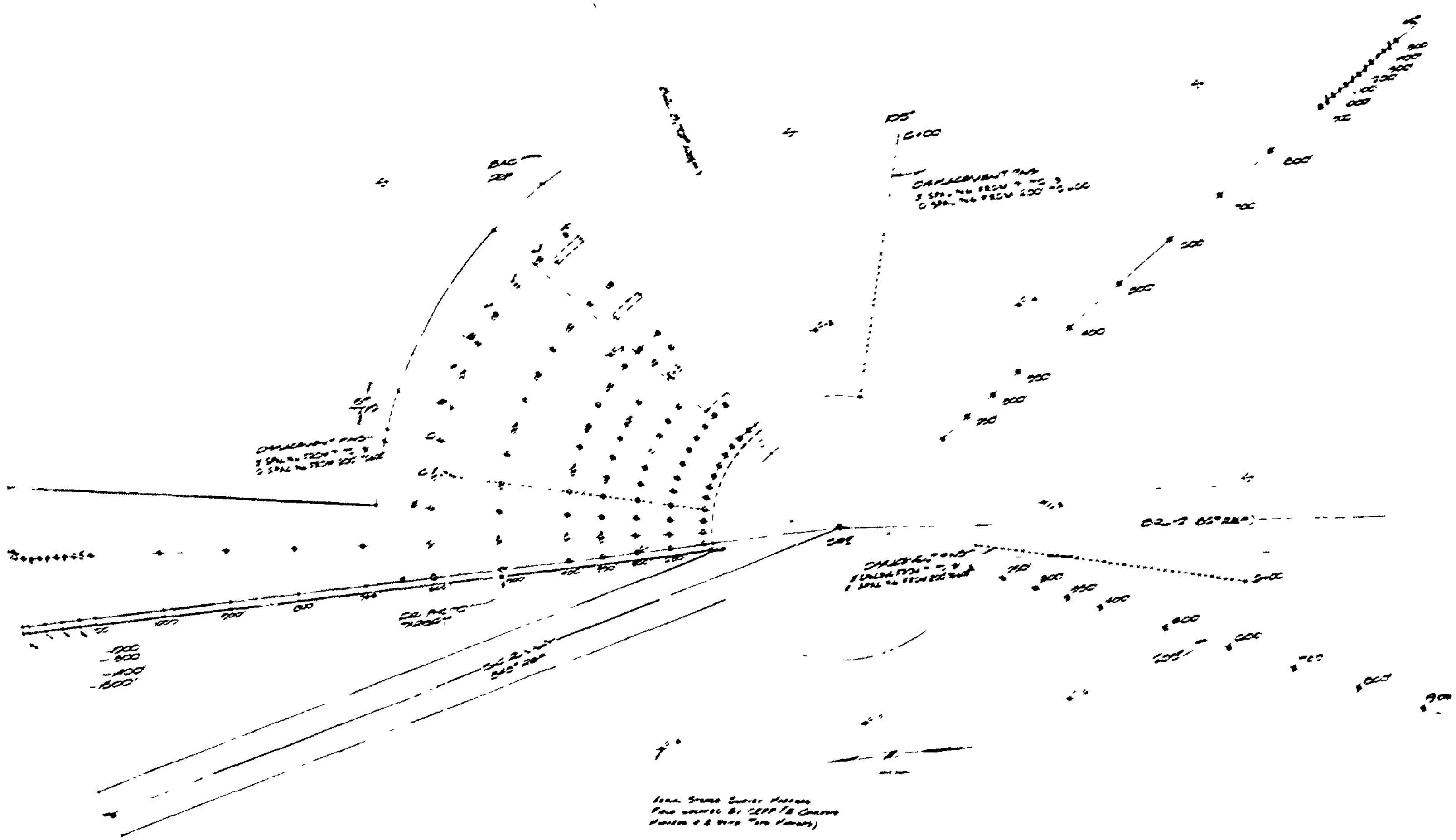


Figure 3-29. AFWL/CERF Experiment Layout, DICE THROW

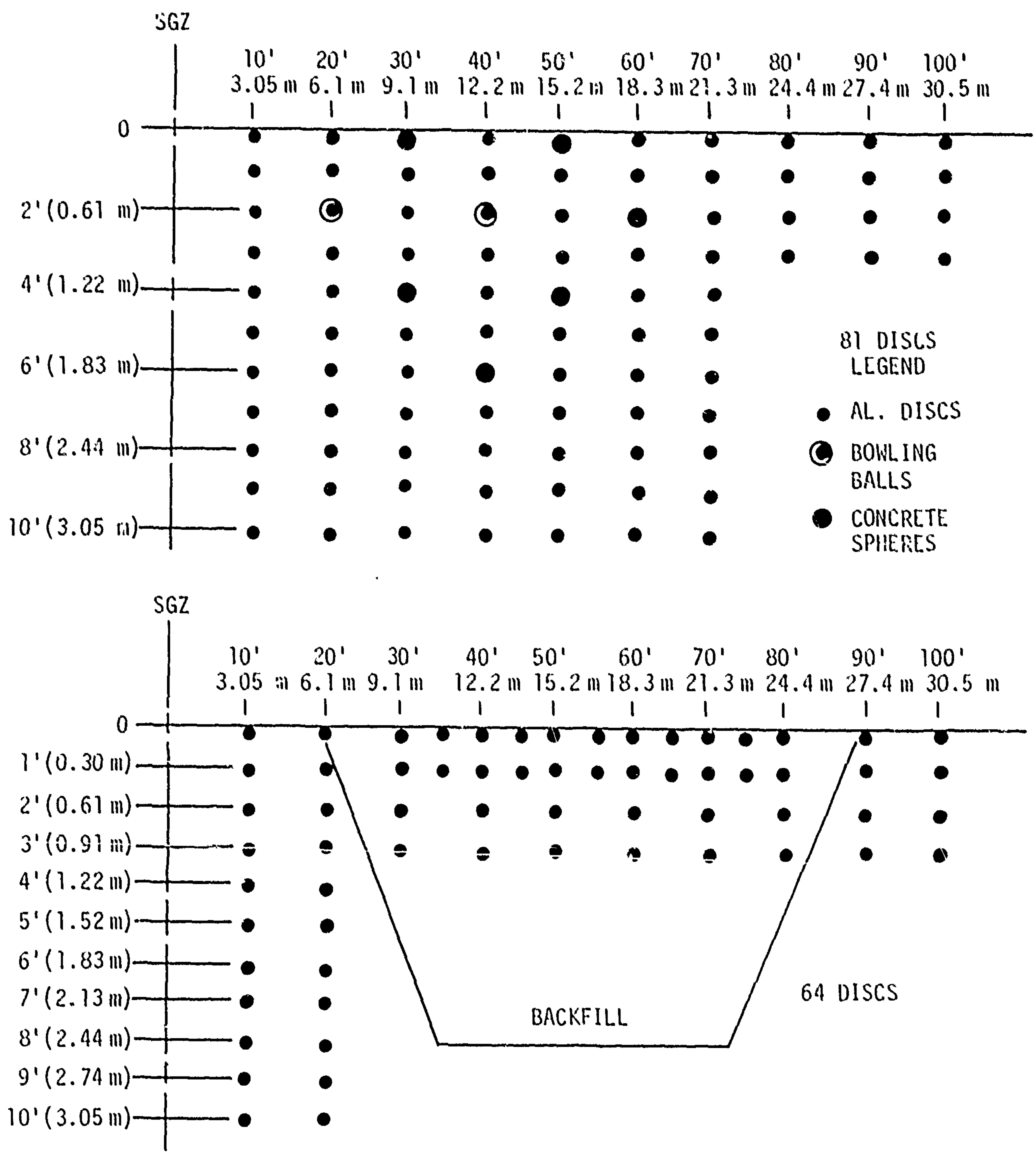


Figure 3-30. AFWL/CERF Artificial Missiles Layout, DICE THROW

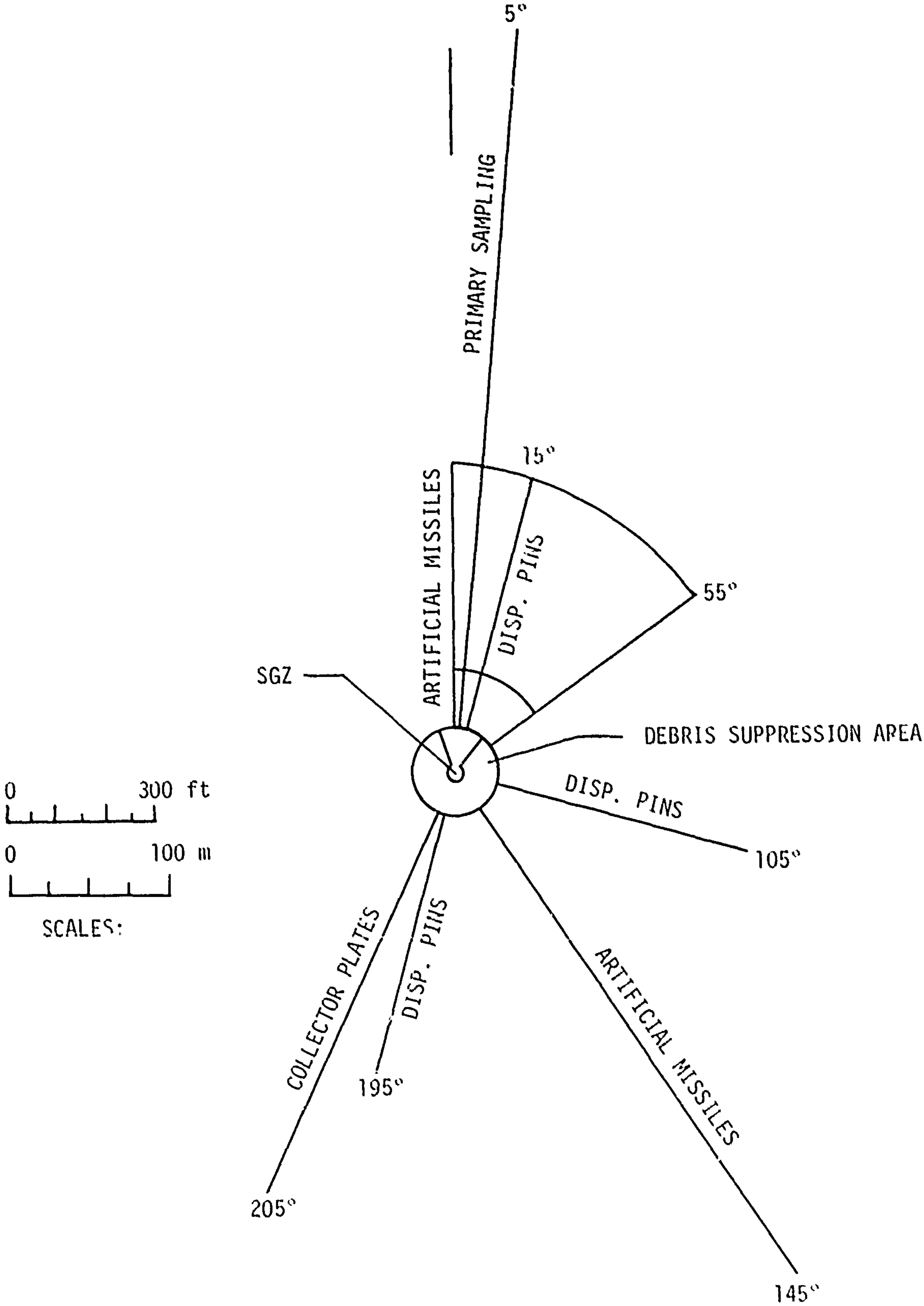


Figure 3-31. AFWL/CERF Plan View of Experiment, DICE THROW

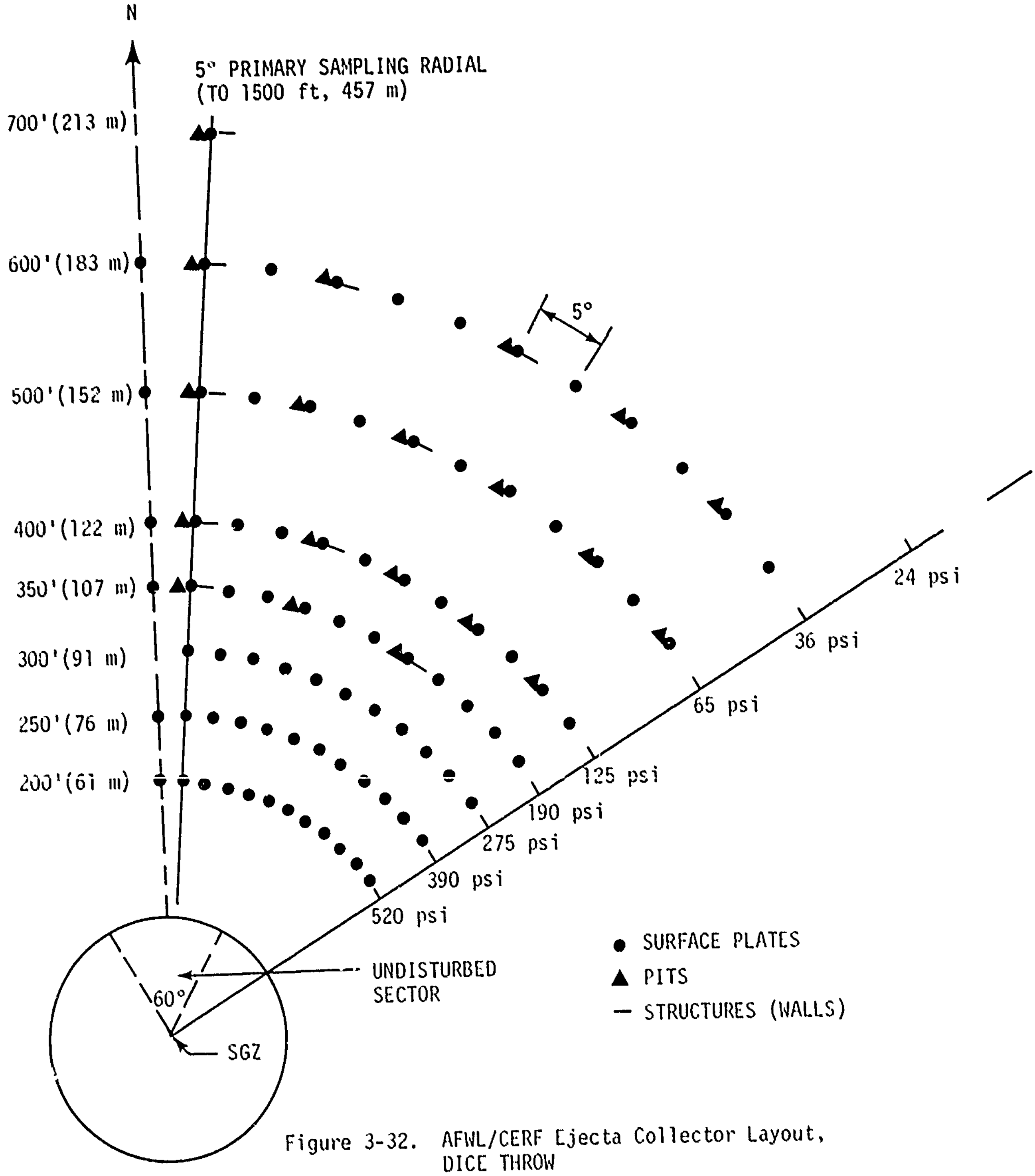


Figure 3-32. AFWL/CERF Ejecta Collector Layout, DICE THROW

four stations each measuring radial and vertical accelerations, and ERIM had twelve stations, most of which were self-recording. An exception to these were the ERIM stations east of GZ, which were recorded in a special instrumentation van located near Highway 20, southeast of GZ. Refer to Figure 3-33 for a map showing locations of these seismic stations.

5. Ballistic Research Laboratory (BRL)

(a) TITLE: Dynamic Airblast Measurements, DNA Project #101

PROJECT OFFICER: Mr. G. Teel (301) 278-3361

OBJECTIVE: Measure the free-field airblast environment from a large-scale ANFO detonation.

EXPERIMENT DESCRIPTION: Instrumentation was installed to record the airblast parameters throughout the pressure range 5000 to 0.5 psi (35,000 to 3.5 kPa). Incident and total head overpressures were recorded both along the ground surface and at various heights above the ground (refer to Figures 3-34 and 3-35). A total of 83 free-field airblast measurements were recorded. The three main gage lines required 69 of these measurements (refer to Figures 3-36 through 3-38 and Tables 3-8, 3-9 and 3-10).

Some of these measurements were made for: AFWL aircraft shelters (3), stations 112, 214 and 219; BRL helicopter experiment (1), station 136; BRL C^3 (7), stations 229, 232 and 235 in location O-2, stations 229, 232 and 235 in location O-3, and station 232 in location O-4; Lovelace Foundation fighting bunker (2), stations 321 and 323; BRL wheeled vehicle area (9), stations 320, 322, 324, 325, 330, 332 and 335 in location O-3, stations 322 and 324; support was also given to DRES and DRI.

(b) TITLE: Blast Effects on In-Flight Helicopter, DNA Project #107

PROJECT OFFICER: Mr. R. Mayerhofer (301) 278-3663

OBJECTIVES: (1) Determine the structural response and rigid body motions of an in-flight helicopter subjected to blast

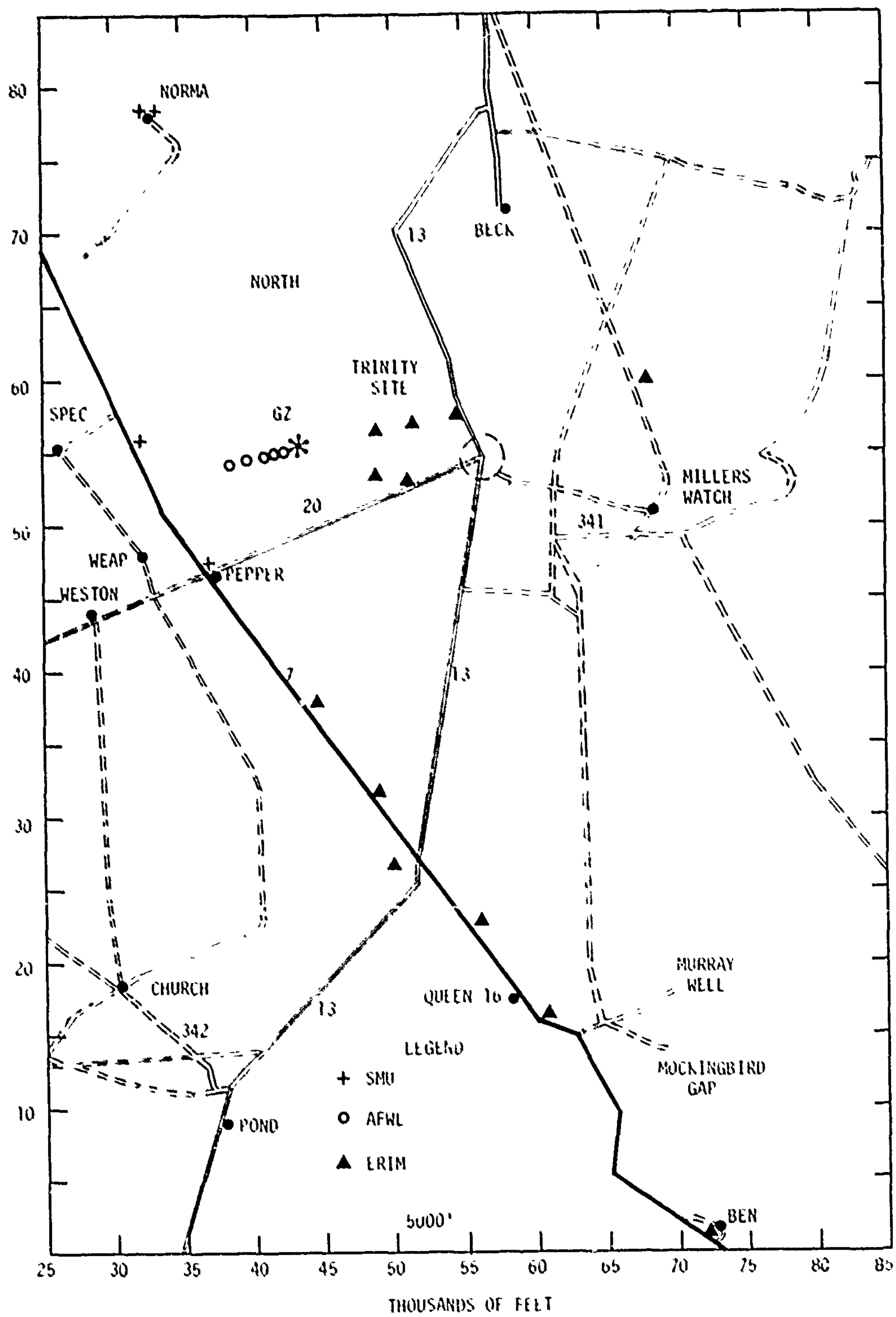


Figure 3-33. AFWL/ERIM/SMU Experiment Layout, DICE THROW

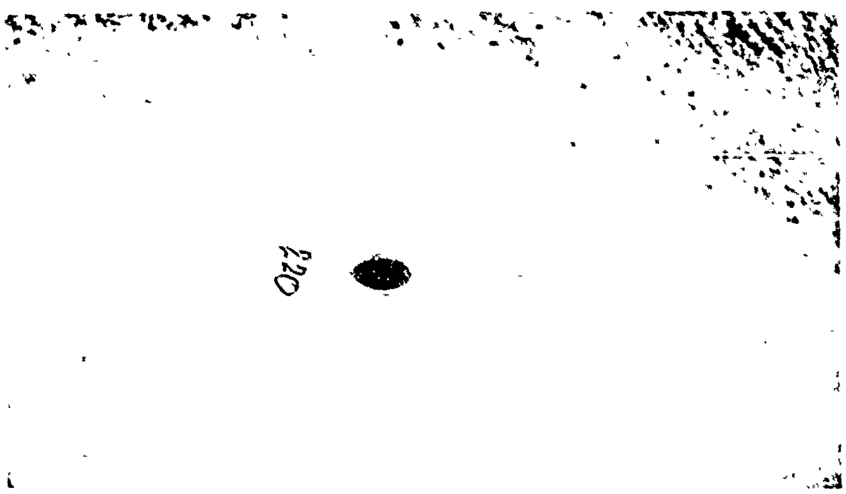


Figure 3-34. BRL Total Head (Top Photo), and Surface Pressure Gages (Bottom Photo) on DICE THROW

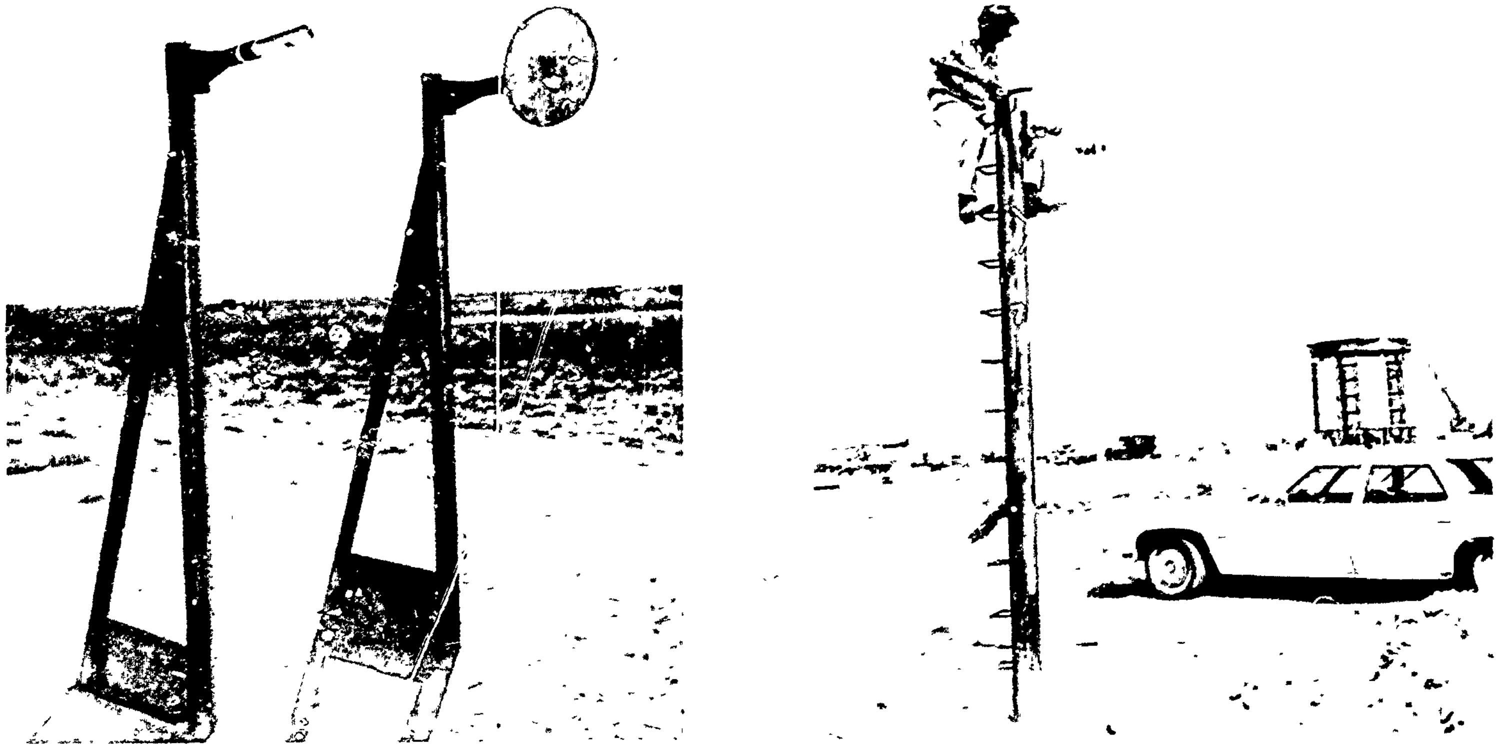


Figure 3-35. BRL Elevated Total Head and Side-On Pressure Gages on DICE THROW

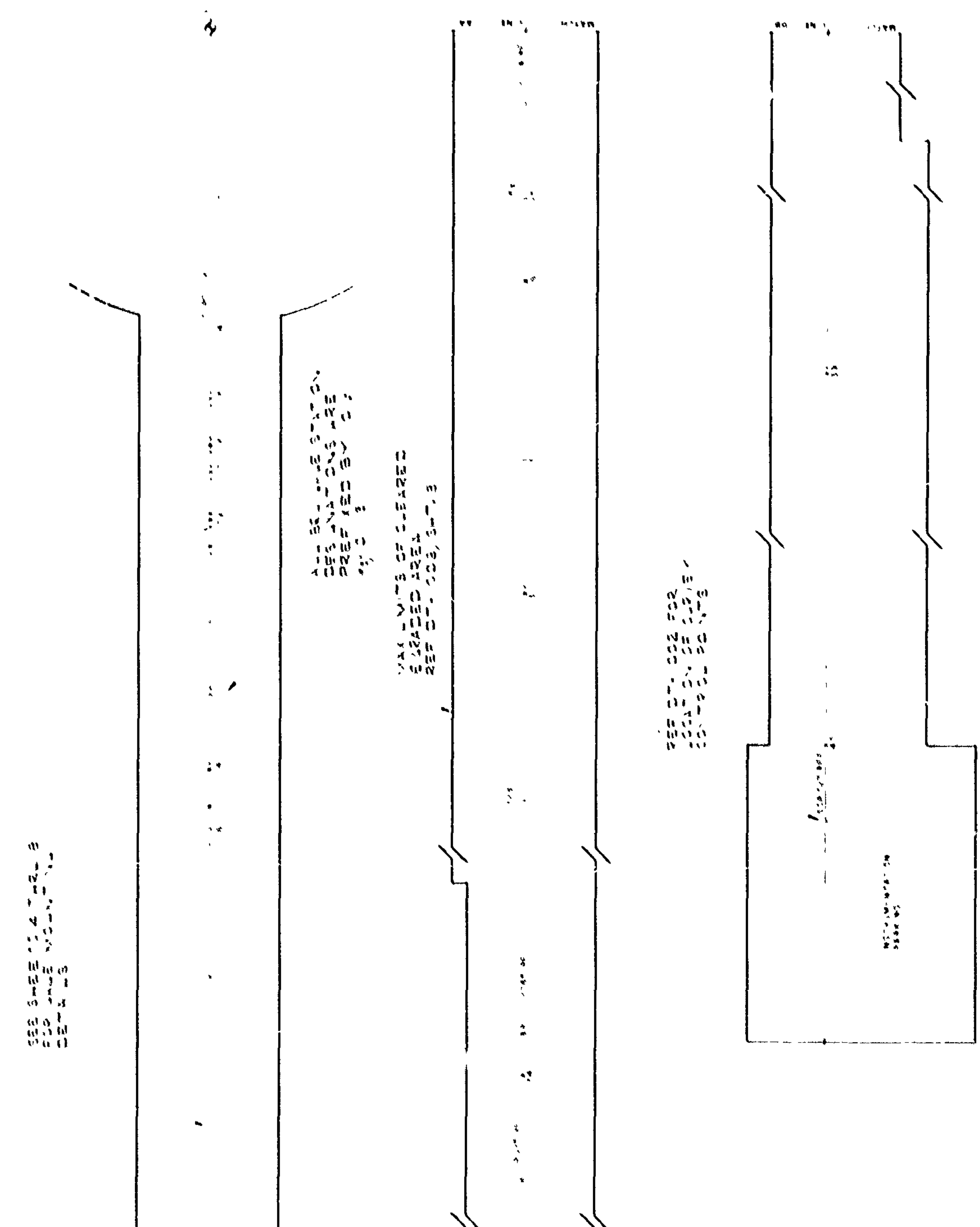


Figure 3-36. BRL Gage Line One, DICE THROW

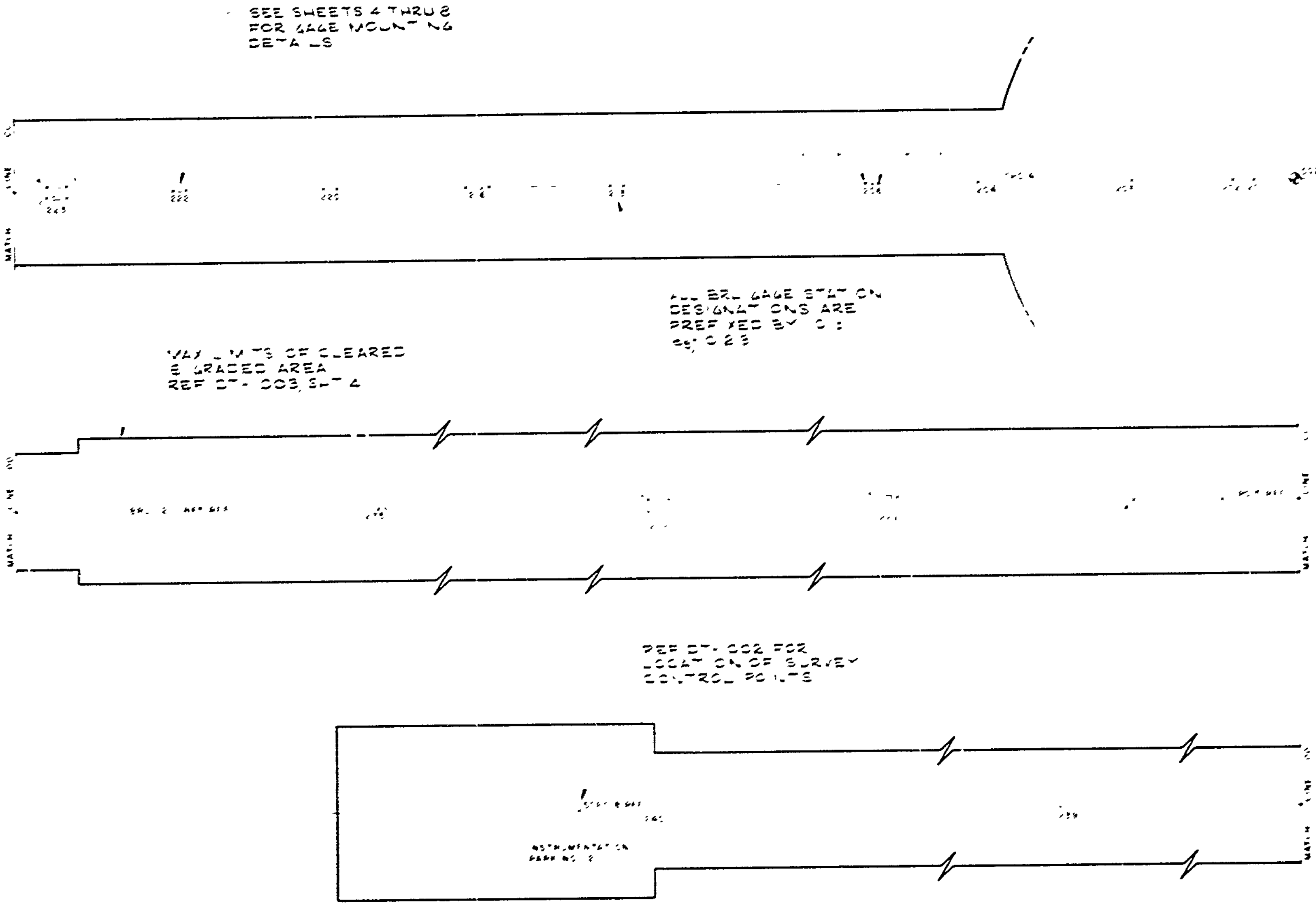


Figure 3-37. BRL Gage Line Two, DICE THROW

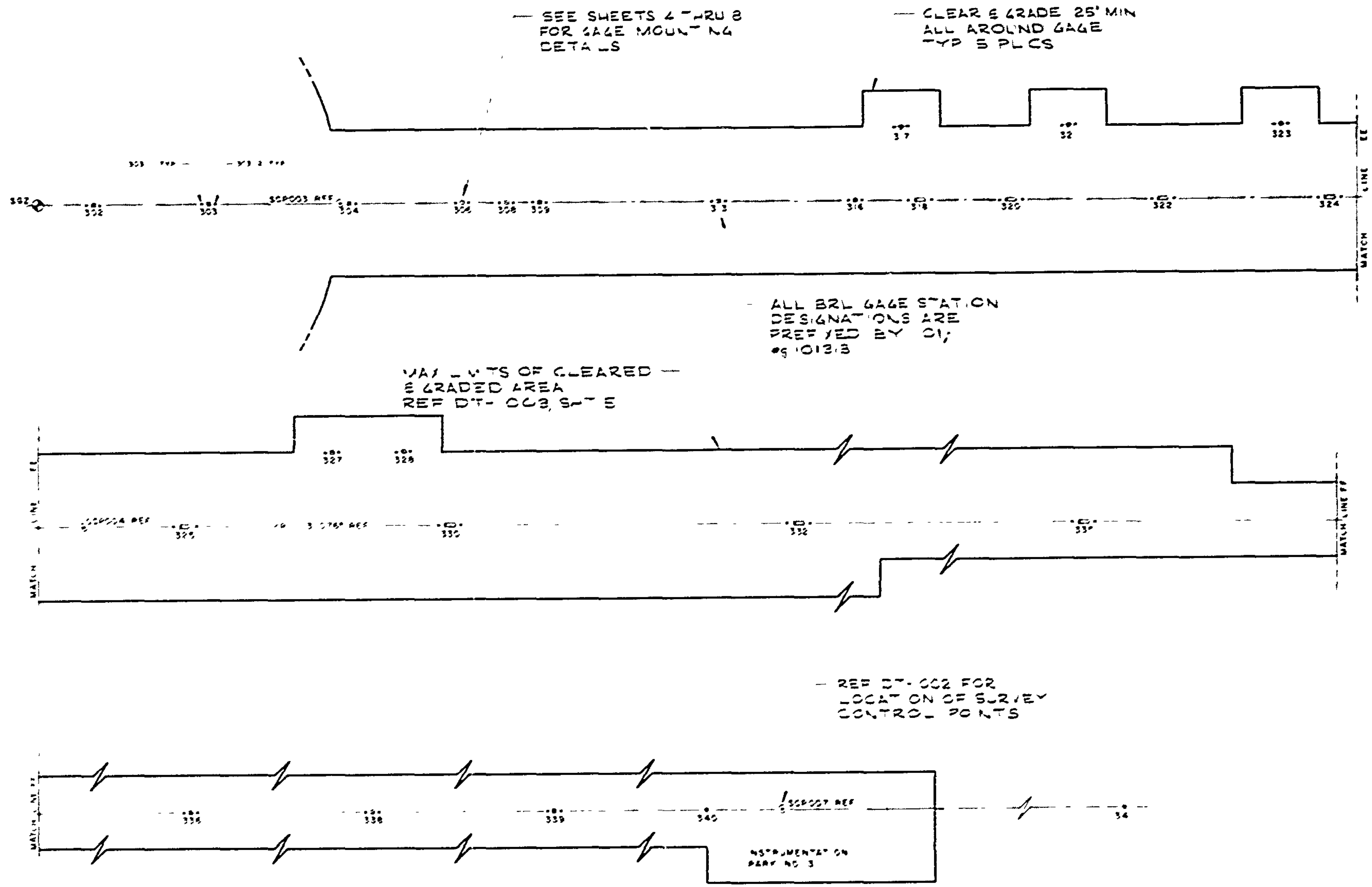


Figure 3-38. BRL Gage Line Three, DICE THROW

Table 3-8. BRL-1 Free-Field Air Blast Gage Locations

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	101	-1 -2	276°00'00"	28.15 ---	-26	II-B-4	5000/32.4
↕	102	-1 -2	↕	--- 41.65	-26	II-B-4	3000/37.4
	103	-1 -2		108.75 117.25	-26	II-B-4	1000/113
	104	-1 -2		199.24+ 210.25	-21	II-A-4	500/206
	105	-1 -2		245.75 254.25	-21	II-A-4	380/250
	106	-1 -2		276.75 285.25	-20	II-A-2	300/281
	107	-1 -2		295.75 304.25	-20	II-A-2	270/300
	108	-1 -2					250/310
	109	-1 -2		327.75 336.25	-20	II-A-2	210/332
	110	-1 -2		345.75 354.25	-20	II-A-2	185/350
	111	-1 -2		395.75 404.25	-20	II-A-2	127/400

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-8. BRL-1 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	112	-1 -2	275°00'00"				100/440
	113	-1 -2		445.00 460.00	-10	I-A	90/450
	114	-1 -2		495.75 504.25	-20	II-A-2	65/500
	115	-1 -2		520.75 529.25	-20	II-A-2	55/525
	116	-1 -2		535.00 550.00	-10	I-A	50/540
	117	-1 -2					45/570
	118	-1 -2					40/580
	119	-1 -2					35/605
	120	-1 -2		635.00 650.00	-10	I-A	30/640
	121	-1 -2					25/680
	122	-1 -2		735.75 744.25	-20	II-A-2	20/740

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 5-8. BRL-1 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	123	-1 -2	276°00'00"	815.75 824.25	-20	II-A-2	15/820
	124	-1 -2					14/850
	125	-1 -2		960.75 969.25	-20	II-A-2	10/965
	126	-1 -2		1015.00 1030.00	-10	I-A	9.0/1020
	127	-1 -2					8.4/1050
	128	-1 -2					7.5/1112
	129	-1 -2					7.3/1120
	130	-1 -2		1135.75 1144.25	-20	II-A-2	7.0/1140
	131	-1 -2		1225.00 1240.00	-10	I-A	6.0/1230
	132	-1 -2		1365.75 1374.25	-20	II-A-2	5.0/1370
	133	-1 -2					4.0/1575

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-8. BRL-1 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	134	-1 -2	276°00'00"	1725.00 1740.00	-10	I-A	3.5/1730
	135	-1 -2		1995.75 2004.25	-20	II-A-2	3.0/2000
	136	-1 -2					2.0/2750
	137	-1 -2					1.8/3000
	138	-1 -2					1.25/4000
	139	-1 -2		4995.75 5004.25	-20	II-A-2	1.0/5000
	140	-1 -2		5950.00** ---	-80	VIII	0.8/6000
101	141	-1 -2	276°00'00"				0.65/7000
101	125a	-1	OFFSET 2' NORTH	965.00	N/A	II-A-2 (PROTOTYPE)	10/965
101	132a	-1	OFFSET 2' NORTH	1370.00	N/A	II-A-2 (PROTOTYPE)	5.0/1370

*SCP
**DISPLACED 50' FROM TRAILER

NOTE 1: FOR ACTUAL AS BUILT GAGE LOCATIONS, SEE DMA COMPUTER PRINTOUT 614-76

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-9. BRL-2 Free-Field Air Blast Gage Locations

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	201	-1 -2	186°00'00"	28.15 ---	-21	II-A-4	5000/32.4
	202	-1 -2		--- 41.65	-21	II-A-4	3000/37.4
	203	-1 -2		108.75 117.25	-21	II-A-4	1000/113
	204	-1 -2		199.29* 210.25	-21	II-A-4	500/206
	205	-1 -2					380/250
	206	-1 -2		276.75 285.25	-20	II-A-2	300/281
	207	-1 -2					270/300
	208	-1 -2					25C/310
	209	-1 -2					210/332
	210	-1 -2					185/350
	211	-1 -2					127/400

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-9. BRL-2 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	212	-1 -2	186°00'00"				100/440
	213	-1 -2		445.75 454.25	-20	II-A-2	90/450
	214	-1 -2					65/500
	215	-1 -2					55.525
	216	-1 -2		535.00 550.00	-10	I-A	50/540
	217	-1 -2					45/570
	218	-1 -2					40/580
	219	-1 -2					35/605
	220	-1 -2		635.75 644.25	-20	II-A-2	30/640
	221	-1 -2					25/680
	222	-1 -2	186°00'00"	735.75 744.25	-20	II-A-2	20/740

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-9. BRL-2 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	223	-1	185°41'22"	817.00	-50	V-8	15/820
		-2	185°41'22"	830.50			
		-3	186°18'38"	817.00	-50	V-8	
		-4	186°18'38"	830.50			
	224	-1					14/850
		-2					
	225	-1	186°00'00"	960.00	-10	I-A	10/965
		-2		975.00			
	226	-1					9.0/1020
		-2					
	227	-1					8.4/1050
		-2					
	228	-1					7.5/1112
		-2					
	229	-1	185°46'21"	1117.00	-50	V-8	7.3/1120
		-2	185°46'21"	1130.50			
		-3	186°13'39"	1117.00	-50	V-8	
		-4	186°13 39"	1130.50			
	230	-1					7.0/1140
		-2					
	231	-1					6.0/1230
		-2					

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-9. BRL-2 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	232	-1 -2 -3 -4	185°54'59" 185°54'59" 186°05'01" 186°05'01"	1367.00 1380.50 1367.00 1380.50	-50 -50	V-8 V-8	5.0/1370
↓	233	-1 -2					4.0/1575
↓	234	-1 -2					3.5/1730
↓	235	-1 -2	186°00'00"	1997.00 2010.50	-50	V-8	3.0/2000
↓	236	-1 -2	↓				2.0/2750
↓	237	-1 -2	↓				1.8/3000
↓	238	-1 -2	↓				1.25/4000
↓	239	-1 -2	↓	4995.75 5004.25	-20	II-A-2	1.0/5000
↓	240	-1 -2	↓	5950.00** ---	-80	VIII	0.8/6000
101	241	-1 -2	186°00'00"				0.65/7000

*SCP
**DISPLACED 50' FROM TRAILER

NOTE
1 FOR ACTUAL AS BUILT GAGE LOCATIONS, SEE DMA COMPUTER PRINTOUT 614-76

1 m = 3.28 ft 1 psi = 6.89 kPa

Table 3-10. BRL-3 Free-Field Air Blast Gage Locations

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	3RL Type	NOMINAL OP/GR
101	301	-1 -2	76°00'00"				5000/32.4
	302	-1 -2		33.15 41.65	-21	II-A-4	3000/37.4
	303	-1 -2		108.75 117.25	-21	II-A-4	1000/113
	304	-1 -2		198.65* 210.25	-21	II-A-4	500/206
	305	-1 -2					380/250
	306	-1 -2		276.75 285.25	-20	II-A-2	300/281
	307	-1 -2					270/300
	308	-1 -2		305.75 314.25	-20	II-A-2	250/310
	309	-1 -2		327.75 336.25	-20	II-A-2	210/332
	310	-1 -2					185/350
	311	-1 -2					127/400

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-10. BRL-3 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	312	-1 -2	76°00'00"				100/440
	313	-1 -2		445.75 454.25	-20	II-A-2	90/450
	314	-1 -2					65/500
	315	-1 -2					55/525
	316	-1 -2	76°00'00"	535.75 544.25	-20	II-A-2	50/540
	317	-1 -2	70°58'17" 70°58'17"	565.75 574.25	-20	II-A-2	45/570
	318	-1 -2	76°00'00"	575.00 590.00	-10	I-A	40/580
	319	-1 -2					35/605
	320	-1 -2	76°00'00"	635.00 650.00	-10	I-A	30/640
	321	-1 -2	71°47'00" 71°47'00"	675.75 684.25	-20	II-A-2	25/680
	322	-1 -2	76°00'00" 76°00'00"	735.00 750.00	-10	I-A	20/740

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-10. BRL-3 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
10?	323	-1 -2	72°30'15" 72°30'15"	815.75 824.25	-20	II-A-2	15/820
	324	-1 -2	76°00'00"	845.00 860.00	-10	I-A	14/850
	325	-1 -2		960.00 975.00	-10	I-A	10/965
	326	-1 -2	76°00'00"				9.0/1020
	327	-1 -2	73°16'14" 73°16'14"	1045.75 1054.25	-20	II-A-2	8.4/1050
	328	-1 -2	73°25'22" 73°25'22"	1107.75 1116.25	-20	II-A-2	7.5/1112
	329	-1 -2	76°00'00"				7.3/1120
	330	-1 -2		1135.00 1150.00	-10	I-A	7.0/1140
	331	-1 -2					6.0/1230
	332	-1 -2		1365.00 1380.00	-10	I-A	5.0/1370
	333	-1 -2					4.0/1575

1 m = 3.28 ft
1 psi = 6.89 kPa

Table 3-10. BRL-3 Free-Field Air Blast Gage Locations (Continued)

REFERENCE POINT			AZIMUTH	DISTANCE	GAGE MOUNT		
PROJ. NO.	BRL GAGE STA.	PT.	D.M.S. FROM GRID NORTH	FEET FROM SGZ	FCDNA No. DT-1025:	BRL Type	NOMINAL OP/GR
101	334	-1 -2	76°00'00"				3.5/1730
	335	-1 -2		1995.00 2010.00	-10	I-A	3.0/2000
	336	-1 -2		2745.75 2754.25	-20	II-A-2	2.0/2750
	337	-1 -2					1.8/3000
	338	-1 -2		3995.75 4004.25	-20	II-A-2	1.25/4000
	339	-1 -2		4995.75 5004.25	-20	II-A-2	1.0/5000
	340	-1 -2		5950.00** ---	-80	VIII	0.8/6000
101	341	-1 -2	76°00'00"	7000.00 ---	-80	VIII	0.65/7000

*SCP
**DISPLACED 50' FROM TRAILER

NOTE 1: FOR ACTUAL AS BUILT GAGE LOCATIONS, SEE DMA COMPUTER PRINTOUT 614-76

1 m = 3.28 ft
1 psi = 6.89 kPa

loading and compare the resultant data with predictions made by computer modeling; (2) compare the response of newly developed transparent armor to the response of conventional Plexiglas observed on MIXED COMPANY.

EXPERIMENT DESCRIPTION: A tethered drone UH-1B helicopter with 56 channels of structural and rigid body motion instrumentation (strain gages, pressure transducers, accelerometers and gyros) was flown in a hover configuration at 50 - 60 ft (15.2 - 18.3 m) altitude side-on to the blast wave propagation (refer to Figures 3-39 and 3-40). Eighteen strain measurements were made on the main and tail rotor and the instrument panel. Bending was measured with one gage on the tail boom and one gage on the vertical fin. Internal and external blast pressure measurements were made at two locations on the tail boom. The main and tail rotors RPMs were recorded as well as the flap angle. To measure the Rigid Body Motion, there were acceleration gages placed at each axis at the center of gravity. Attitudes (pitch, yaw and roll), attitude rates (pitch, yaw and roll), and altitudes were recorded. Measurements were made of the control positions and tether loading.

The instrumentation was "hard wired" to four magnetic tape recorders located at a manned control bunker. The helicopter was viewed by two cameras on the ground and by two onboard cameras. An additional camera was used inside the control bunker to record the drone pilot's response and to view the drone control panel. Free-field blast measurements were made in the immediate vicinity of the helicopter. A complete transparent armor kit was installed on the drone helicopter and an additional helicopter (UH-1B), also with a transparent armor kit installed, was included in the project as a static ground

Figure 3-39. In-Flight Helicopter Control Bunker, Remote Pilot Position (Top Photo), and Recording Instruments (Bottom Photo), DICE THROW

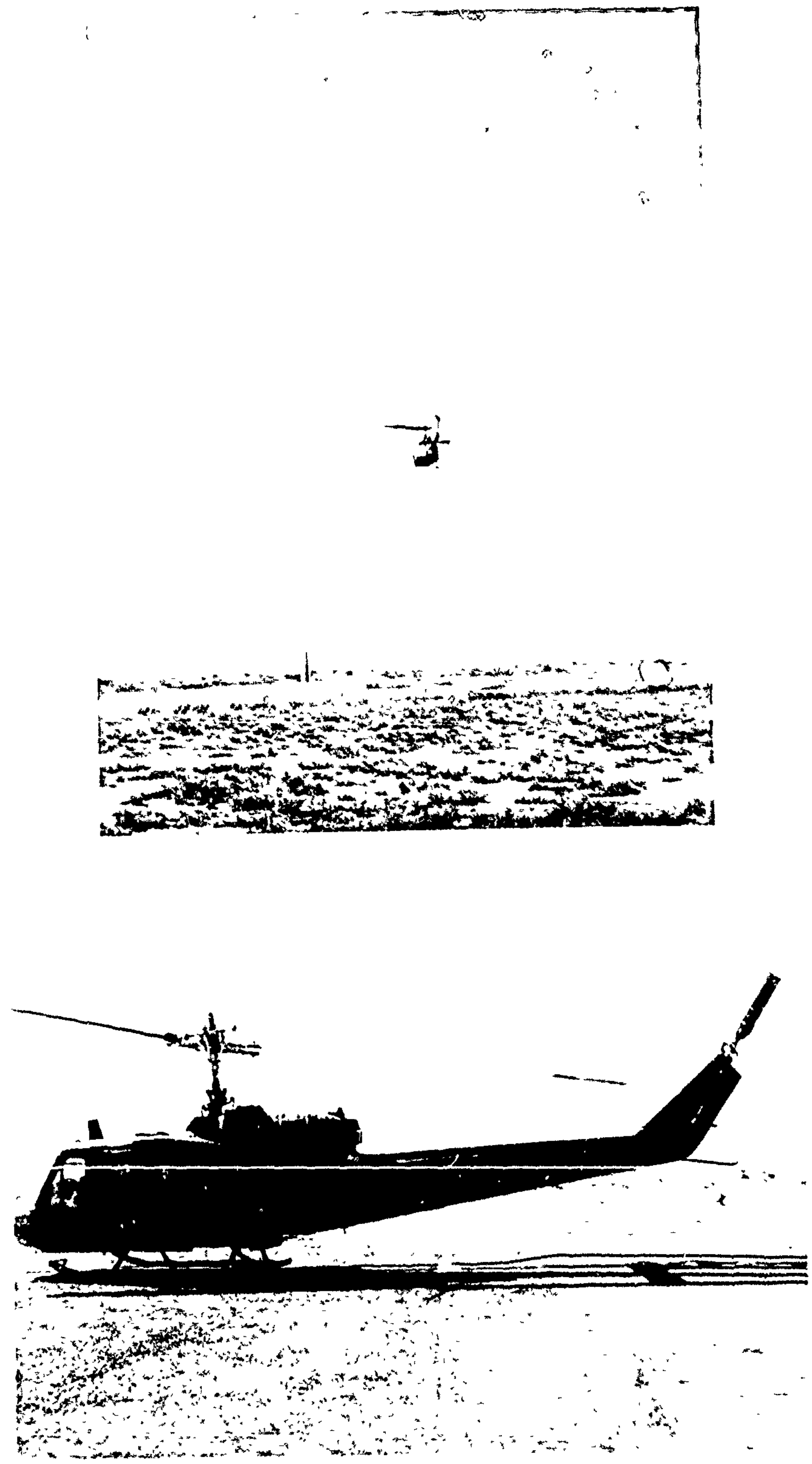


Figure 3-40. In-Flight Helicopter Experiment, DICE THROW

target (refer to Figure 3-41). Instrumentation for the static helicopter consisted of motion picture coverage from two cameras and from internally mounted styrofoam blocks that acted as fragment catchers. Refer to Figure 3-42 for layout details of this experiment.

(c) TITLE: Blast Effects on U. S. Army Wheeled Vehicles, DNA Project #034

PROJECT OFFICER: Mr. R. Raley (301) 278-4912

OBJECTIVES: (1) Determine damage versus distance and associated blast parameters for U. S. wheeled vehicles; (2) correlate such damage with past nuclear test data and with current prediction techniques; (3) record movement of large vehicle targets for evaluation and improvement of motion prediction techniques.

EXPERIMENT DESCRIPTION: Refer to Figure 3-43 for an overall view of this experiment. Twenty 1/4-ton trucks, fifteen 2-1/2-ton trucks, and two vans were exposed to the airblast. Obsolete, 1/4-ton (M-38) vehicles were selected because these models were exposed on past, above ground, nuclear tests. The M-38 jeeps for operation DICE THROW were obtained from excess property depots located throughout the U. S. (refer to Figure 3-44 for photographs of some of these test items).

The originally selected M35A-2 2-1/2-ton trucks were chosen as desirable targets because they represented a current class of cargo vehicle; a vehicle whose cargo can include large electronic shelters. However, these models were not available and older model M35's were used. Primary investigations indicated that damage and response of an M35 could be directly related to the damage and response incurred by an M35A-2 if both were subjected to the same blast loading.

The vehicular targets were exposed to the air blast at overpressure levels ranging from 3 to 40 psi (21 to

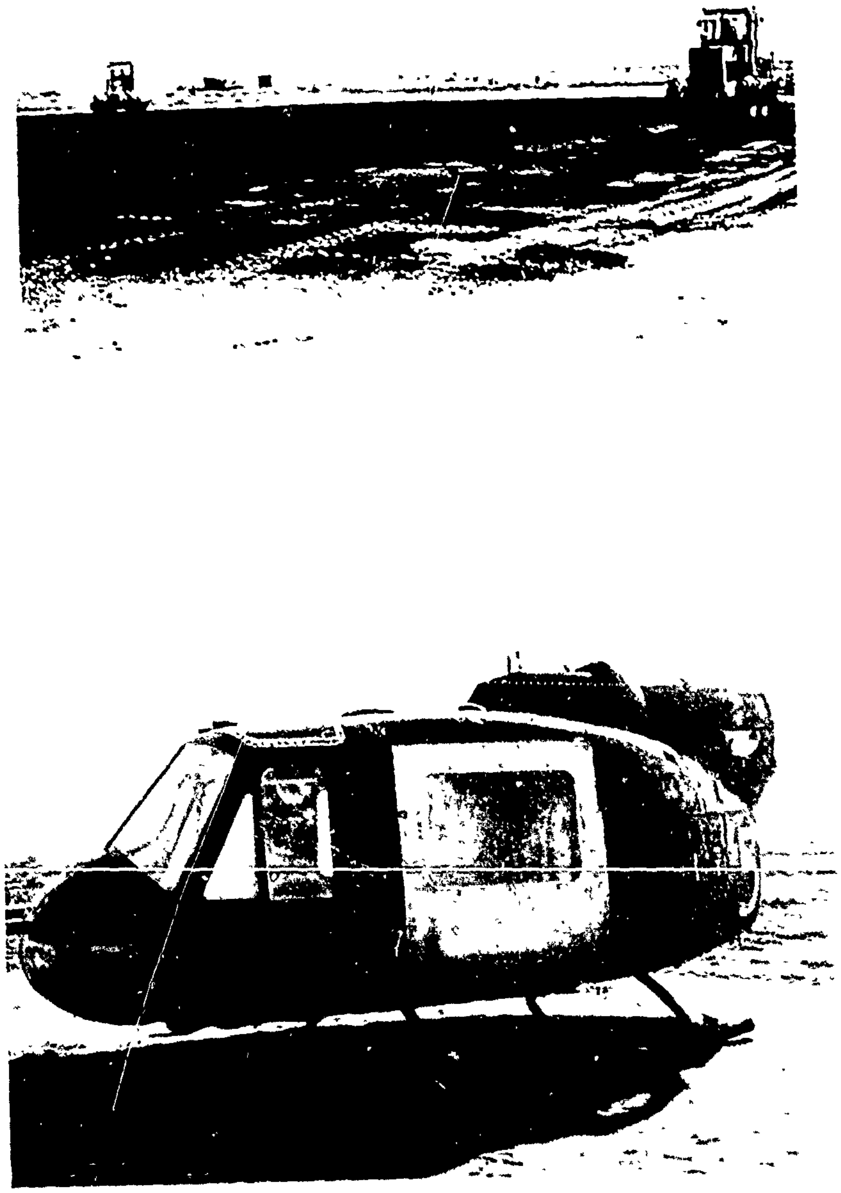


Figure 3-41. BRL Remote Control Helicopter Pad During Construction (Top Photo), Static Helicopter with Transparent Armor Kit (Bottom Photo) on DICE THROW

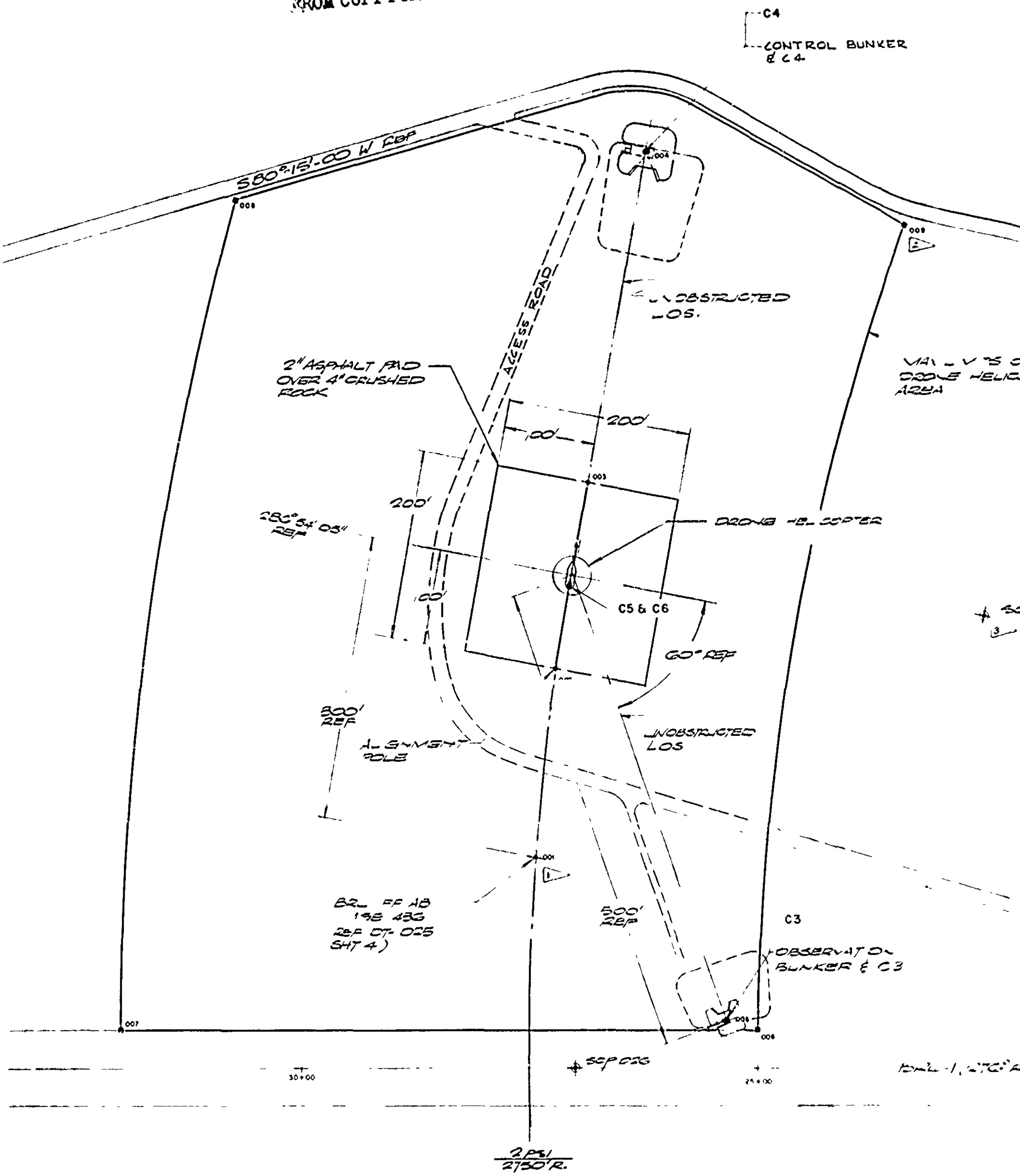
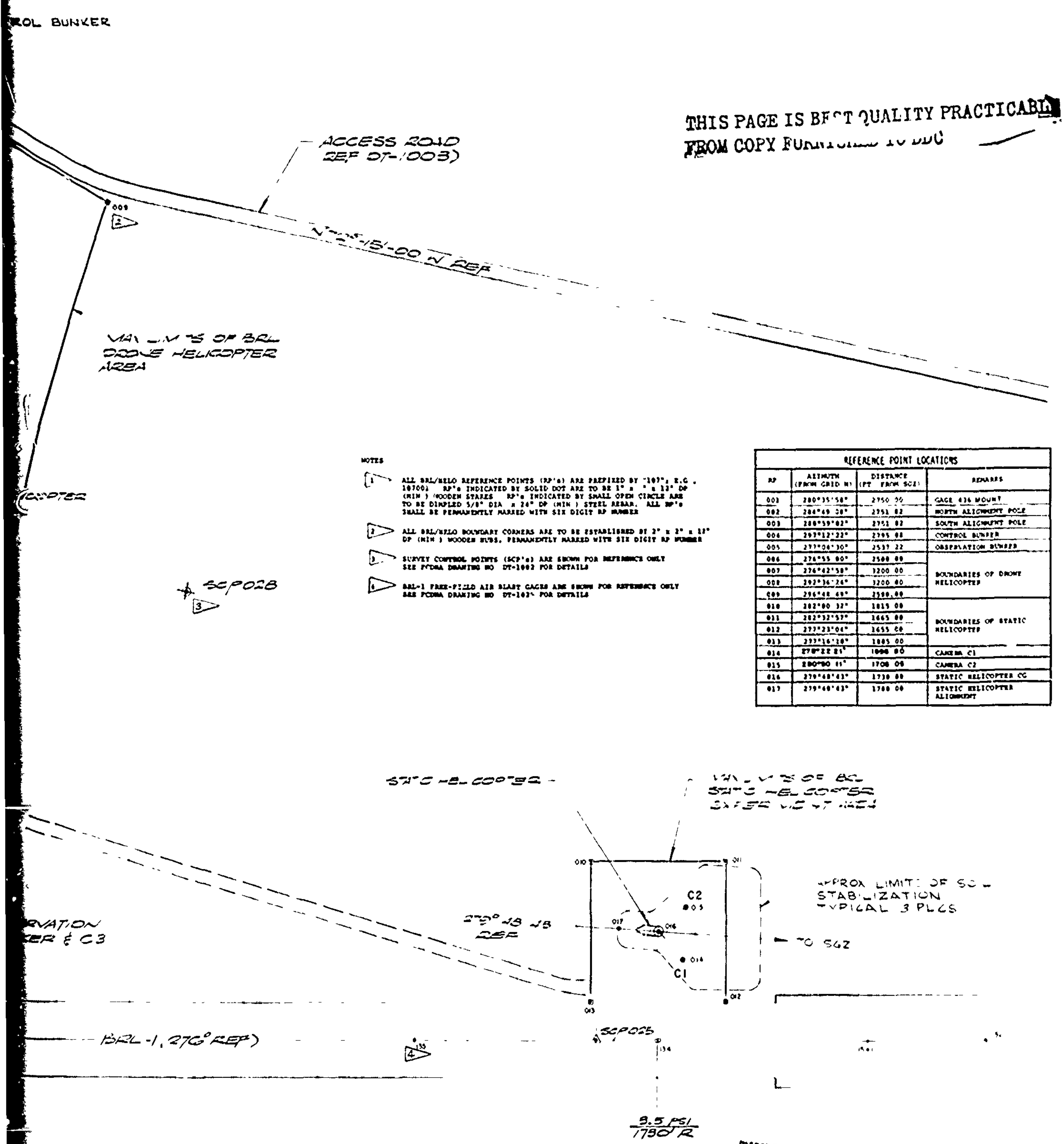


Figure 3-42. BRL Helicopter Experiment Layout, DICE THROW



NOTES

1. ALL BRL/HELO REFERENCE POINTS (RP's) ARE PREFIXED BY "107"; E.G. 107001. RP's INDICATED BY SOLID DOT ARE TO BE 1" x " x 12" DP (MIN) WOODEN STAKES. RP's INDICATED BY SMALL OPEN CIRCLE ARE TO BE DIMPLED 5/8" DIA x 24" DP (MIN) STEEL REBAR. ALL RP's SHALL BE PERMANENTLY MARKED WITH SIX DIGIT RP NUMBER

2. ALL BRL/HELO BOUNDARY CORNERS ARE TO BE ESTABLISHED BY 2" x 2" x 12" DP (MIN) WOODEN HUBS, PERMANENTLY MARKED WITH SIX DIGIT RP NUMBER

3. SURVEY CONTROL POINTS (SCP's) ARE SHOWN FOR REFERENCE ONLY SEE FCDNA DRAWING NO DT-1002 FOR DETAILS

4. BRL-1 FREE-FIELD AIR BLAST GAGES ARE SHOWN FOR REFERENCE ONLY SEE FCDNA DRAWING NO DT-1025 FOR DETAILS

REFERENCE POINT LOCATIONS

RP	AZIMUTH (FROM GRID N)	DISTANCE (FT FROM SGZ)	REMARKS
001	280°35'58"	2750 00	GAGE 436 MOUNT
002	284°49 30"	2751 02	NORTH ALIGNMENT POLE
003	280°59'02"	2751 02	SOUTH ALIGNMENT POLE
004	293°12'22"	2795 08	CONTROL BUNKER
005	277°04'30"	2537 22	OBSERVATION BUNKER
006	276°55 00"	2500 00	BOUNDARIES OF DRONE HELICOPTER
007	276°42'58"	3200 00	
008	292°36'24"	3200 00	
009	296°48 49"	2590.00	
010	282°00 32"	1815 00	BOUNDARIES OF STATIC HELICOPTER
011	282°32'57"	1665 00	
012	277°23'04"	1655 00	
013	277°16'10"	1885 00	
014	278°22 21"	1690 00	CAMERA C1
015	280°00 11"	1708 08	CAMERA C2
016	279°48'43"	1730 00	STATIC HELICOPTER CG
017	279°48'43"	1780 00	STATIC HELICOPTER ALIGNMENT

2

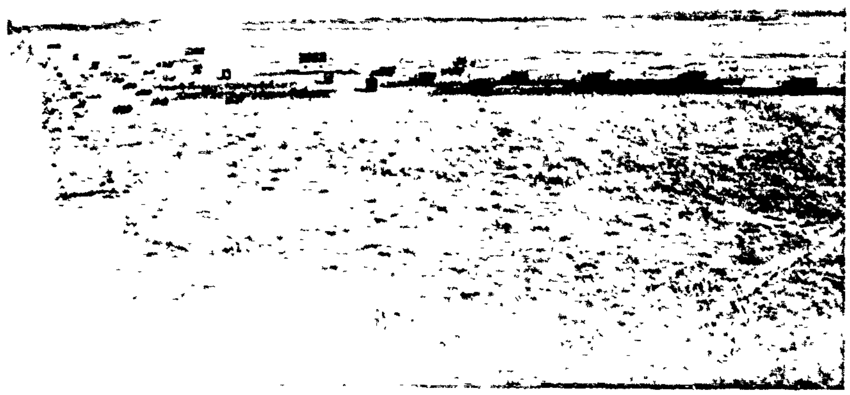


Figure 3-43. BRL U. S. Army Wheeled Vehicles Experiment, DICE THROW

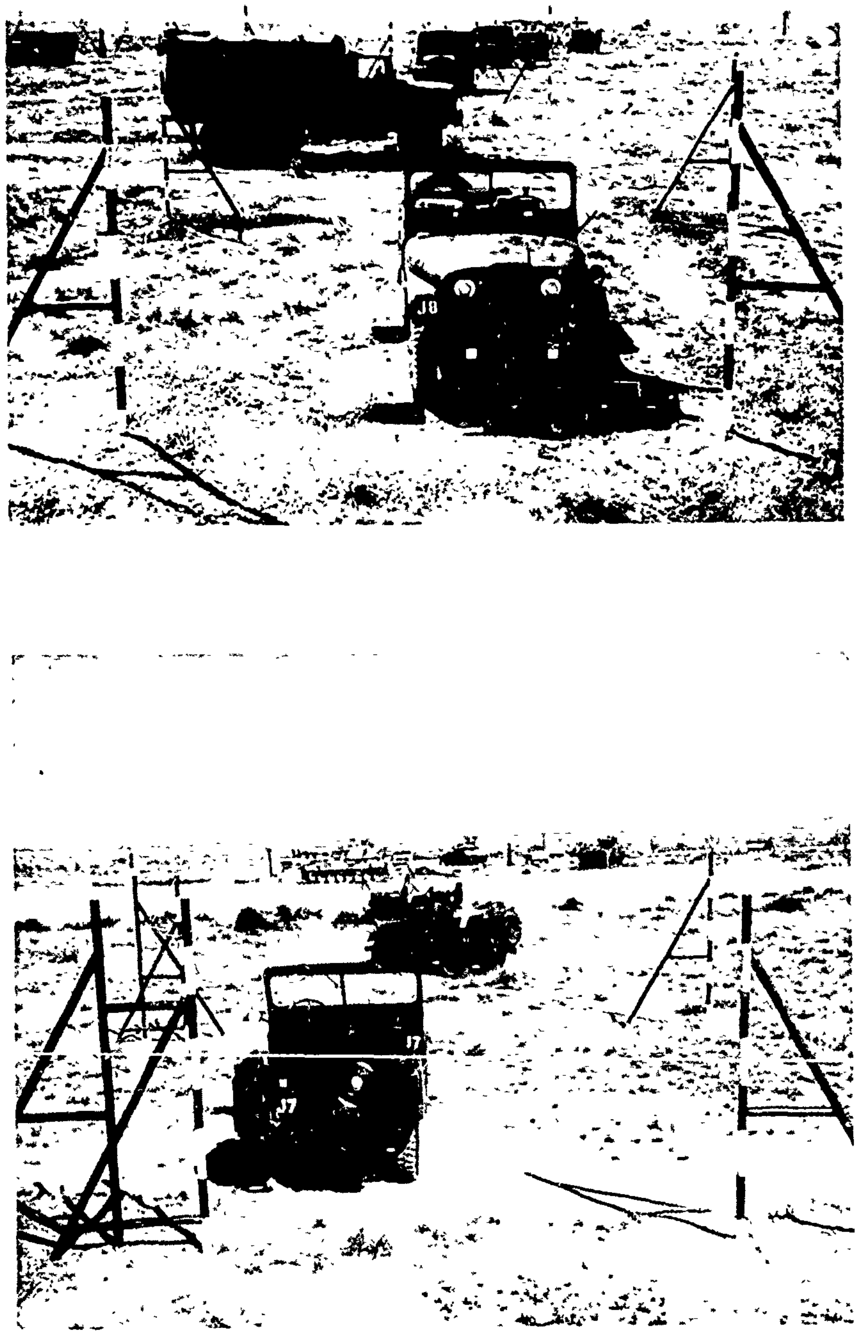


Figure 3-44. BRL U. S. Army Wheeled Vehicles Area with M-38 Jeeps and M-35 2-1/2-ton Trucks, DICE THROW

280 kPa). Damage data obtained from the exposure of both the 1/4-ton and the 2-1/2-ton trucks were to be correlated with similar data obtained during past nuclear tests.

The 1/4-ton jeeps were tested at pressure levels which would cause damage ranging from severe to light, and the 2-1/2-ton vehicles would suffer moderate to light damage. Since it was desired to compare damage to the 2-1/2-ton trucks with past nuclear data, for comparison purposes, two of these vehicles were tested without any cargo load or canvas. However, it was also desired to simulate a current, battlefield ready, cargo truck; thus, the remainder of the 2-1/2-ton vehicles were tested with mock loads and canvas in place.

The response of the vehicles at the 14- and 20-psi (98- and 140-kPa) locations were to be recorded on high-speed motion picture film. These data will be precisely read and used to verify or improve existing vehicular overturning prediction codes. Four of the 2-1/2-ton trucks and two of the jeeps were restrained by a concrete curb so that they would be permitted to overturn but not to slide; this information will also be useful in verifying motion prediction codes.

Overpressure and dynamic pressure was to be measured near each target to insure that the blast wave characteristics were defined. The whole-body motion of selected vehicles was to be recorded by high-speed photography. Ground stabilization was attempted to reduce dust pick-up at the camera stations. The material used was COHEREX, a water emulsion of petroleum resins (refer to Appendix A). Refer to Figure 3-45 for details on experiment layout.

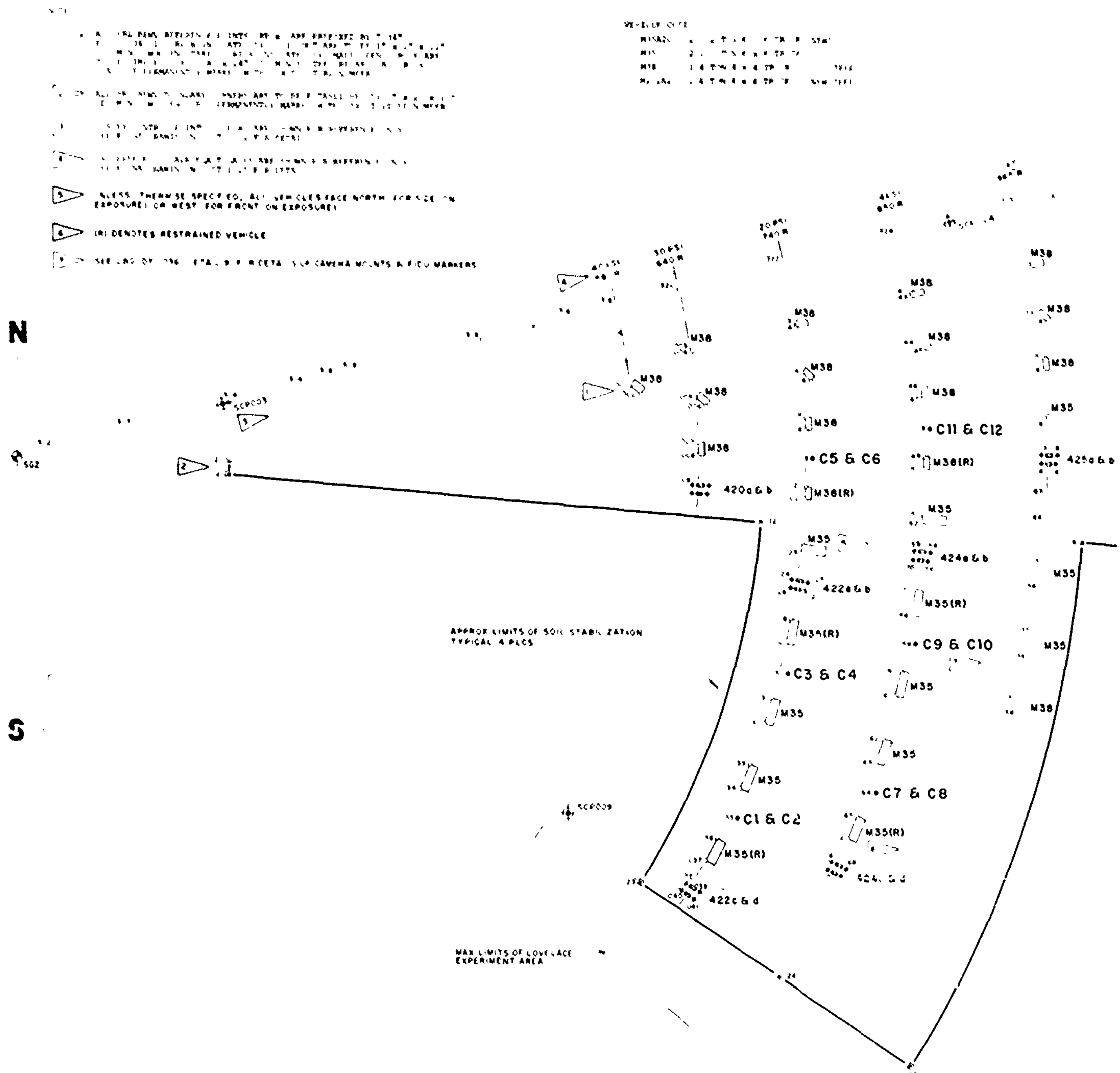
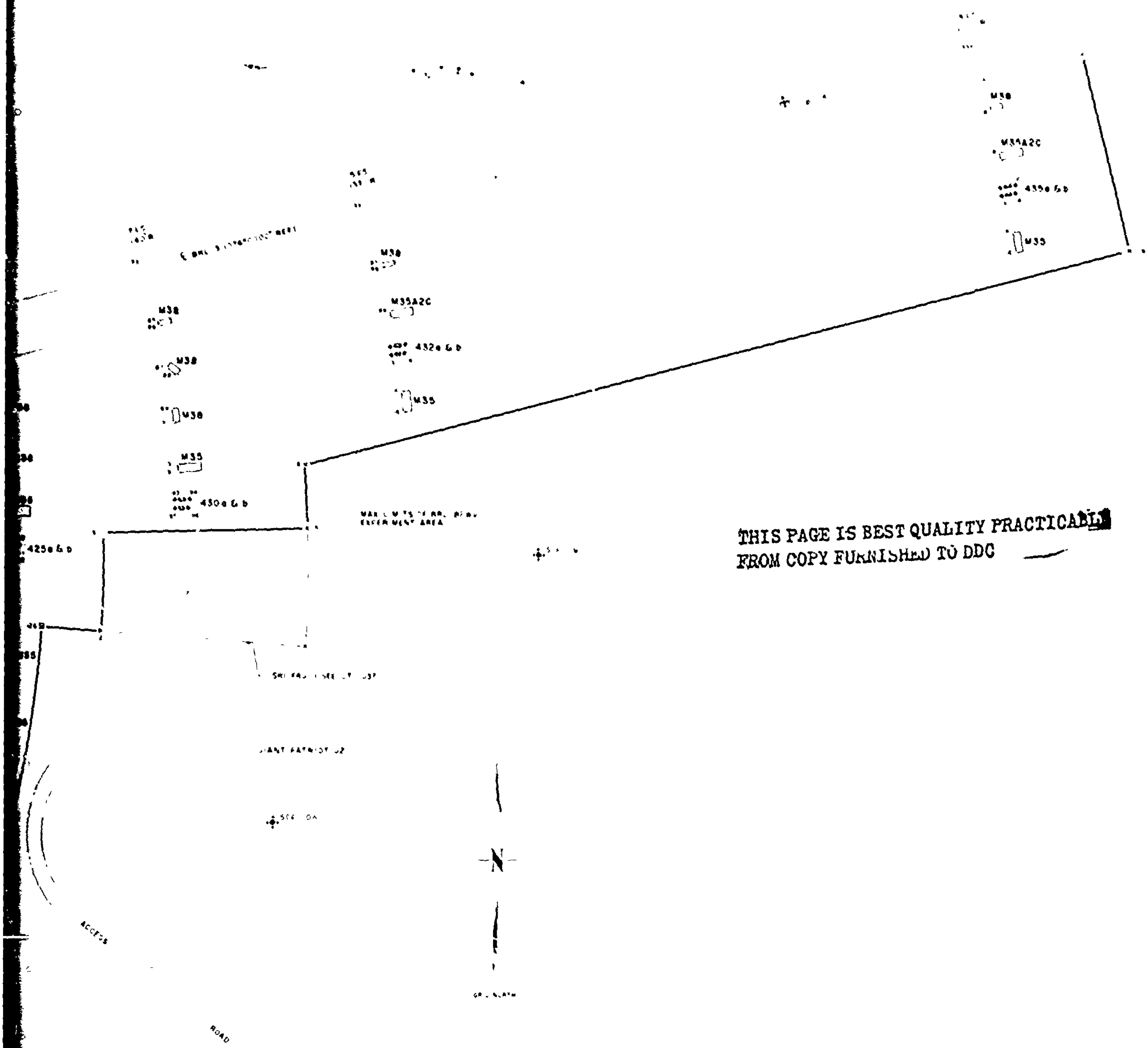


Figure 3-45. BRL U. S. Army Wheeled Vehicles Experiment Layou



Layout

2

6. Ballistic Research Laboratory (BRL)/U. S. Army Electronics Command (ECOM)

TITLE: Vulnerability and Hardening of Command, Control and Communication Shelter Systems, DNA Project #103.

PROJECT OFFICERS: Dr. W. Schuman (301) 278-4320/Mr. R. Freiberg (301) 544-4683.

OBJECTIVES: (1) Determine the vulnerability of current operational tactical signal communication systems. (2) Evaluate retrofit hardened shelter-system designs developed under the U.S. Army Materiel Development Readiness Command (DARCOM) Hardened Shelter Systems Program and obtain data required by that program.

EXPERIMENT DESCRIPTION: Refer to photograph in Figure 3-46 for an overview of this experiment. Figure 3-47 pertains to the details for placement of the test items.

(a) Vulnerability of Operational Tactical Signal Communication Systems Program

Elements of a basic tactical signal communication center were exposed at three pressure levels. Truck-mounted

Figure 3-46. Overview of CCC Experiment, DICE THROW

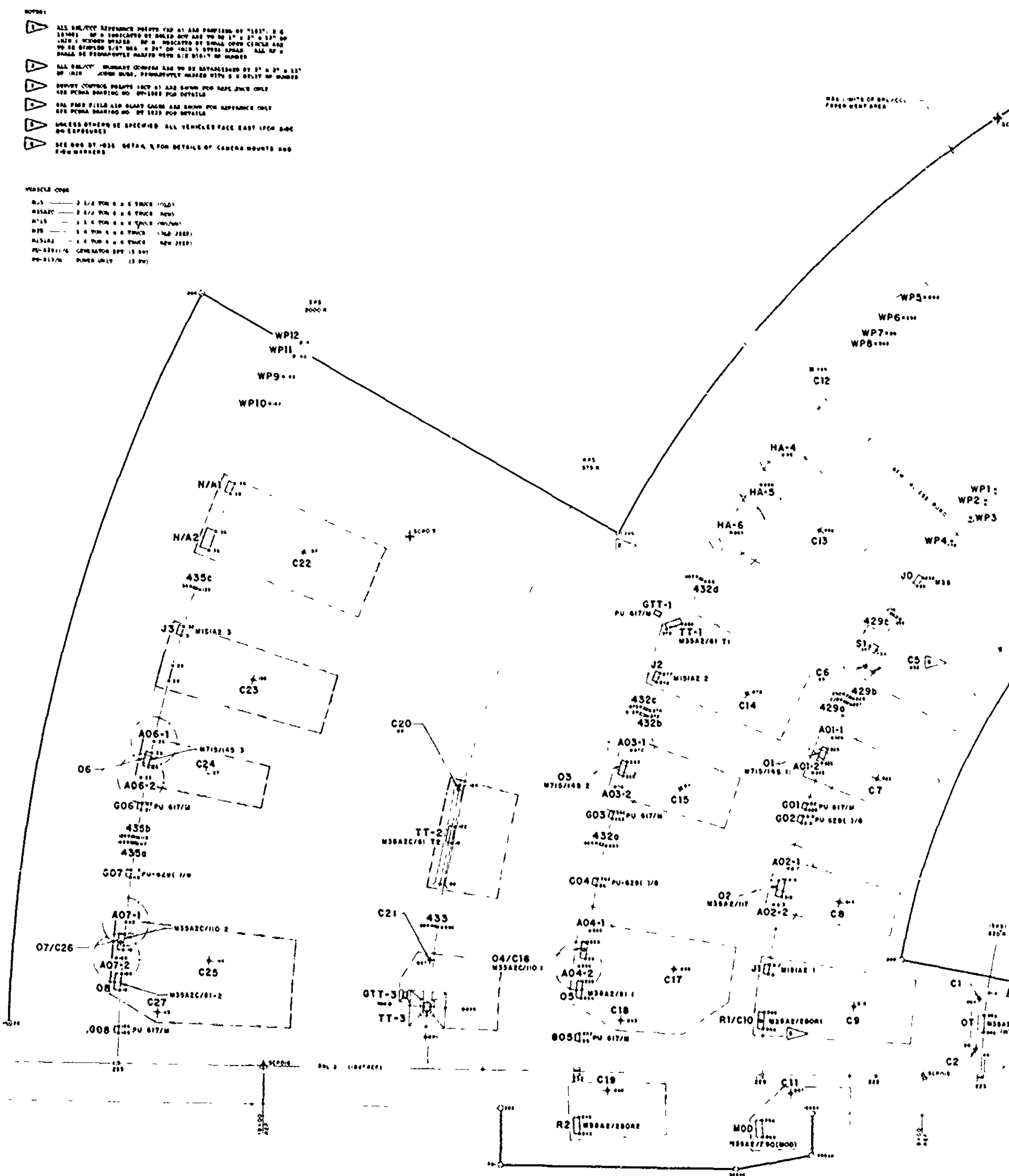
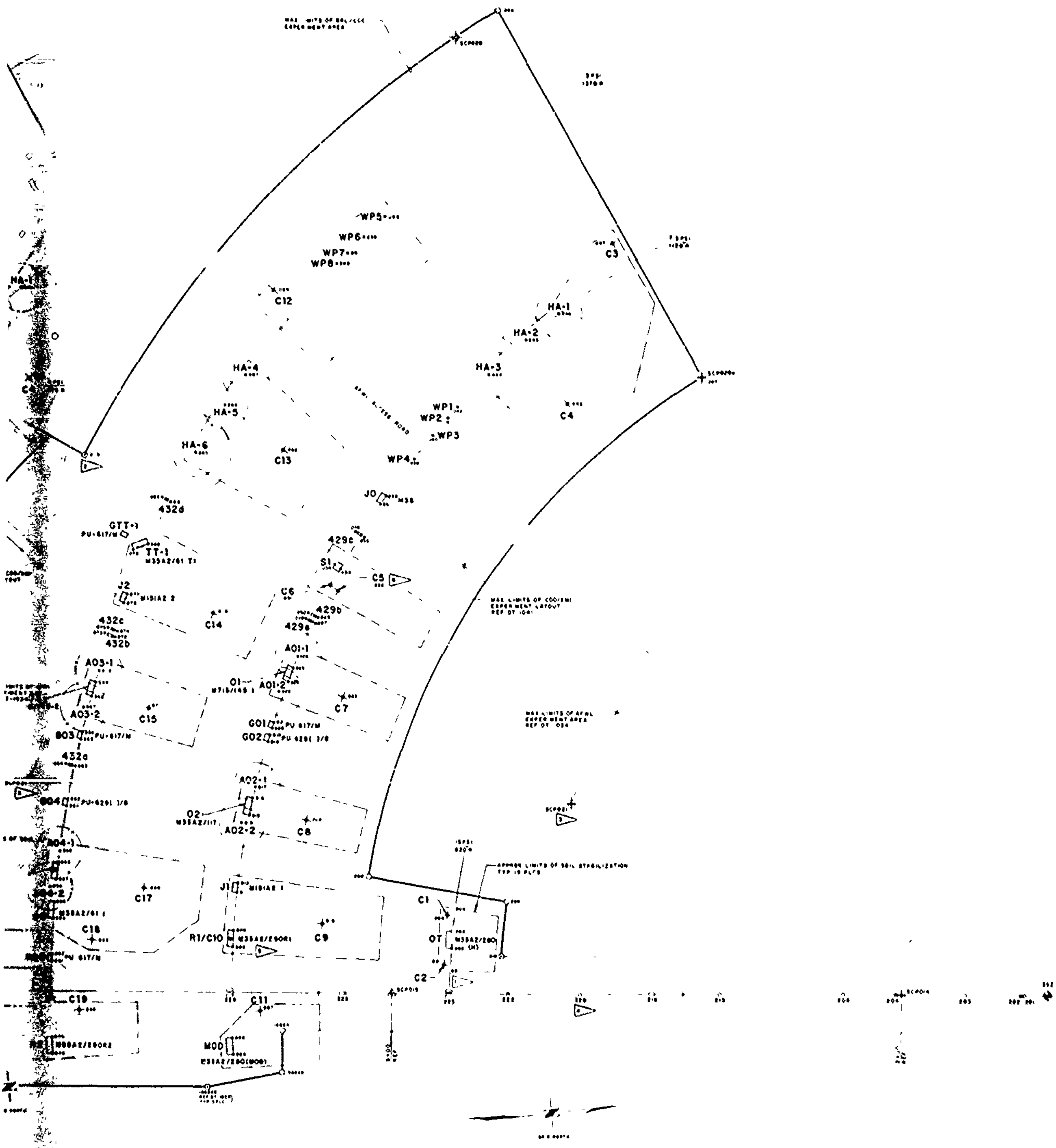


Figure 3-47. CCC Experiment Layout, DICE THROW


WP5
WP6
WP7
WP8
C3
C12
HA-1
HA-2
HA-3
HA-4
HA-5
HA-6
WP1
WP2
WP3
WP4
C4
C13
J0
432d
GTT-1
TT-1
429c
S1
C5
J2
C6
429b
429a
C14
432c
432b
A01-1
A03-1
O1
A01-2
C7
A03-2
C15
G01
G02
G03
432a
A02-1
G04
O2
A02-2
C8
A04-1
C1
J1
C17
C18
R1/C10
C9
OT
C2
C19
C11
MOD

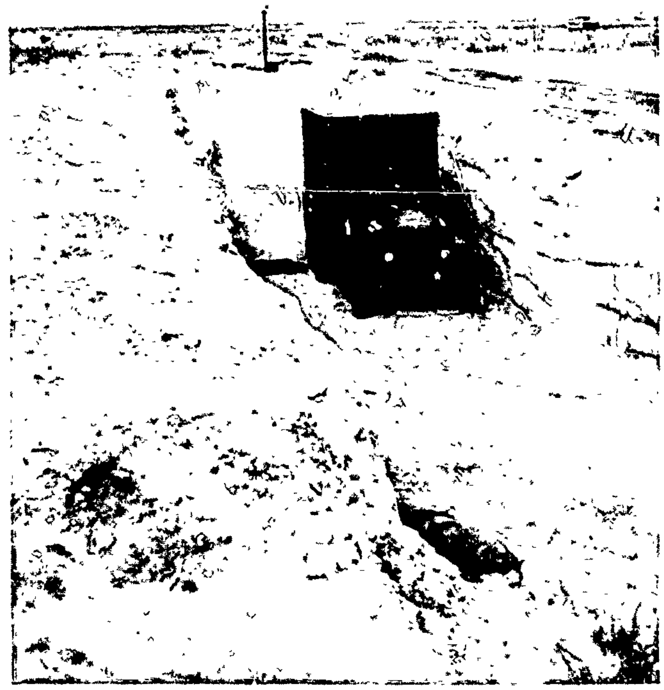
THROW

2

assemblages representing two centers were exposed at each level. The range of levels selected did encompass the range of levels now existing in specifications for these systems. One TRC-145 in an S-250 shelter with its power supply and antenna connected, and a split terminal using TRC-110 and TCC-61 in S-280 shelters with their power supply and antenna, were exposed to a predicted 3-, 5- and 7-psi (21-, 35- and 48-kPa). The S-250's were mounted on a 1-1/4-ton truck, the 280's were mounted on 3/4- and 1-1/2-ton trailers. In addition, there were equipments peculiar to switching and automatic data processing. These assemblages include: the GRC-10' radio, TD-660 multiplexer, patch panels, teletypewriters, and TD-206 pulse restorer in land-lines. The single and split-terminal equipment were turned on; those at 3 psi (21 kPa) were operating over land-lines through the blast period. All equipment was checked operationally before and after the test.

The TRI-TAC switch was mounted in seven S-280 shelters at the predicted 4-psi (28-kPa) level. The shelters were placed on the ground at various orientations, with and without rebutments. The ATACS switch was mounted in two truck-mounted S-280 shelters at the predicted 3- and 5-psi (20- and 35-kPa) levels. Refer to Figures 3-48 and 3-49 showing the S-280 and S-250 shelters in different configurations. The ARTADS modular shelters with some equipment were fielded at the predicted 3- and 5-psi (21- and 35-kPa) levels. A SATCOM hardened, simulated antenna was fielded at the predicted 7.3-psi (51.1-kPa) level (Figure 3-50). One Surgeon General shelter was fielded at the predicted 4-psi (28-kPa) level. The REMBASS sensors were fielded at all four levels. Two Air Force Electronic System Design (ESD) expandable shelters (portable toilets) were fielded at the predicted 4-psi (28-kPa) level (Figure 3-51).

Each of the signal center shelters contained eight accelerometers mounted at critical positions on the electronic



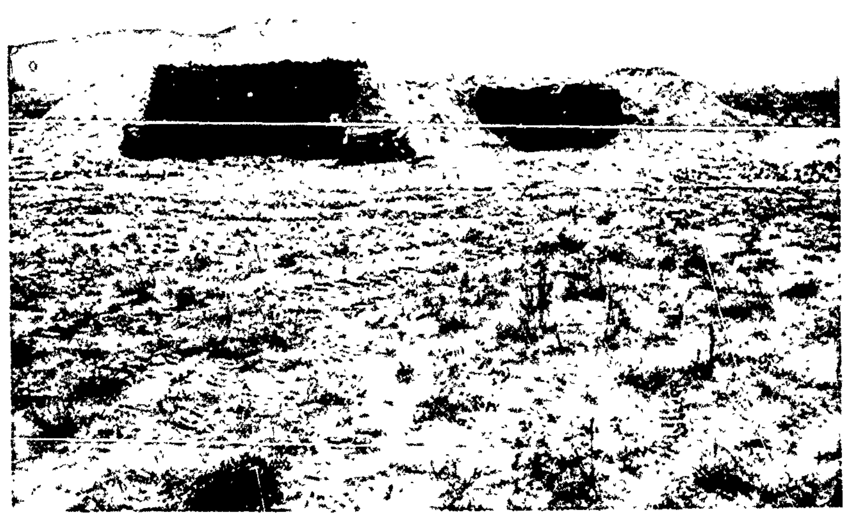


Figure 3-48. CCC Experiment S-280 in Trench (Top Photo), S-280 Sandbagged (Bottom Photo), DICE THROW

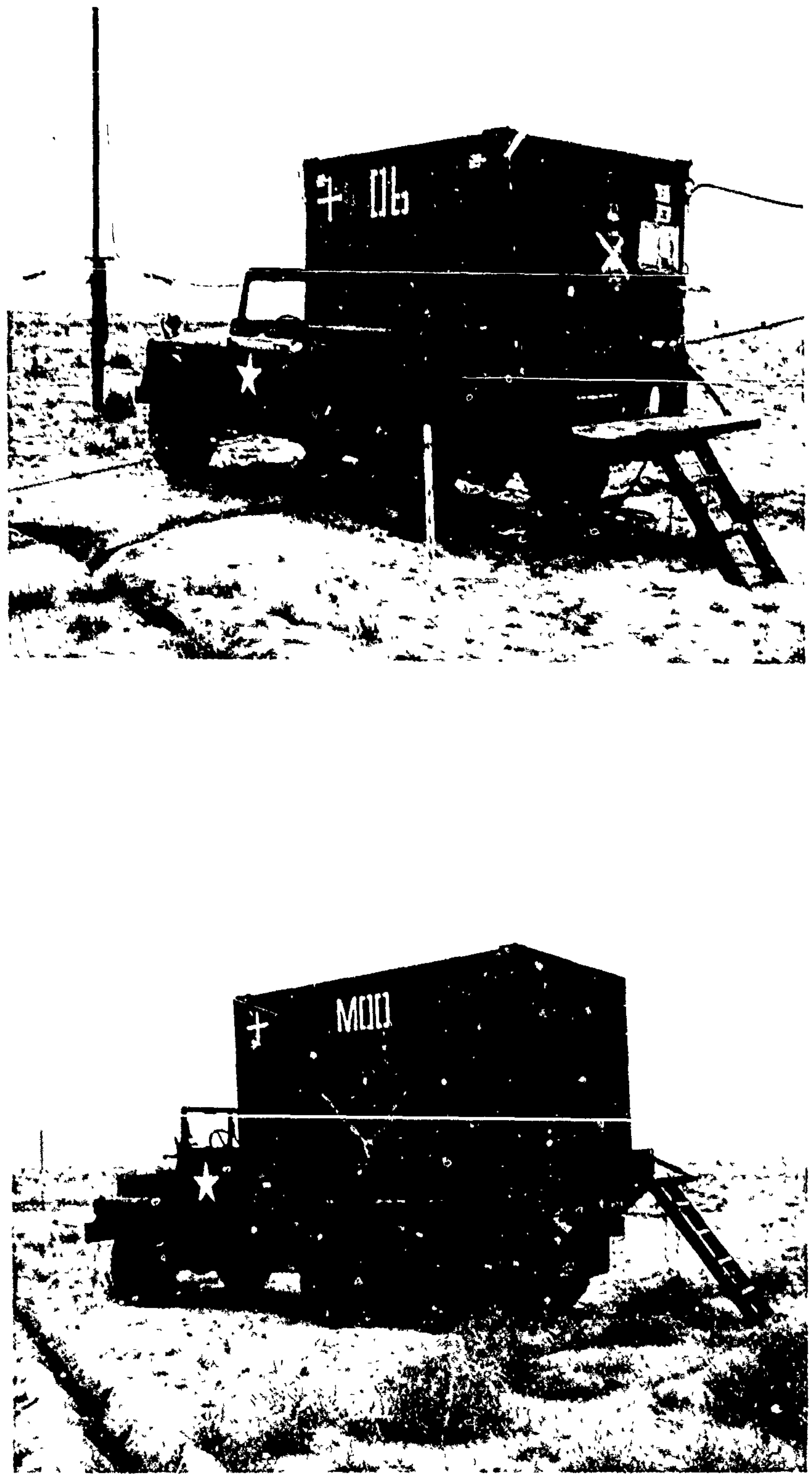
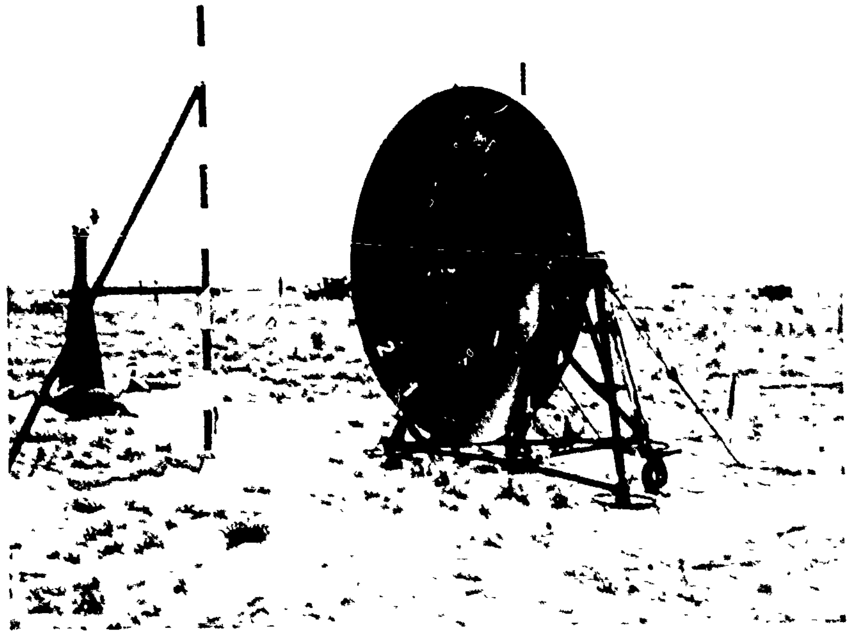


Figure 3-49. CCC Experiment S-250 Shelter (Top Photo), Modular Shelter (Bottom Photo), DICE THROW



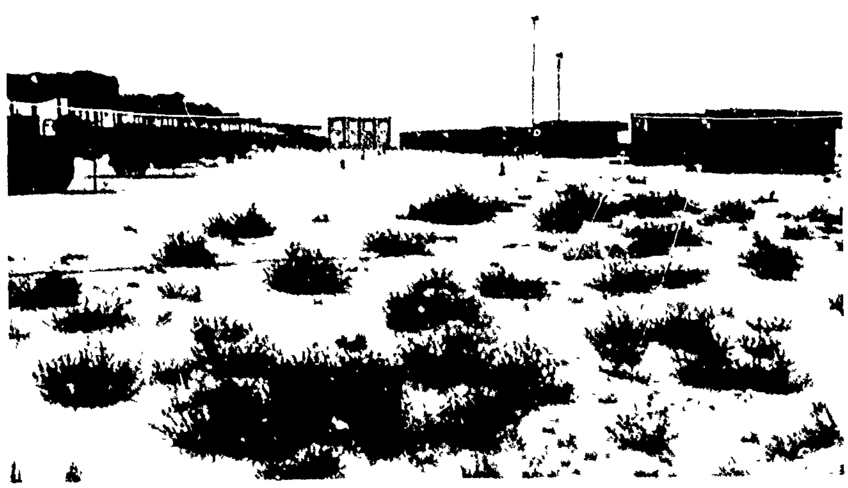


Figure 3-50. CCC Experiment SATCOM Antenna (Top Photo), Receiving Site (Bottom Photo), DICE THROW

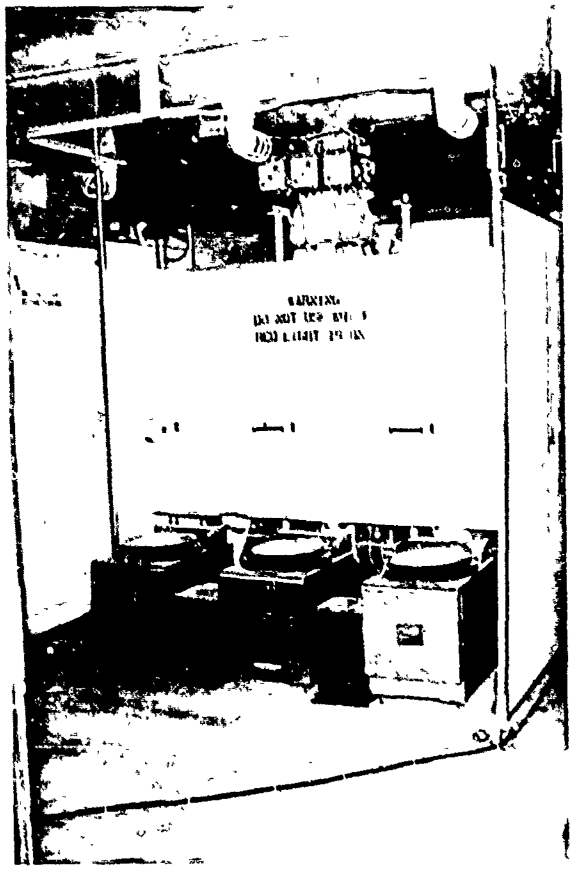


Figure 3-51. CCC Experiment Air Force/ESD Expandable Shelter Inside (Top Photo) and Outside (Bottom Photo), DICE THROW

equipment. Pressure gages measured the loading parameters. Two dummies were placed in each of two S-280 shelters with cameras. The intent was to obtain data at low, medium and high levels of damage. The condition of all equipment was carefully assessed before and after blast exposure.

The TRI-TAC, ATACS and ARTADS shelters contained four accelerometers each. The SATCOM-simulated antenna was instrumented with eight strain gages. The Air Force/ESD contained six deflection gages and three accelerometers.

(b) Shelter Systems Program (Refer to Figures 3-52 and 3-52.)

In order to meet the specific objectives, a number of retrofit S-280 shelters and overturning models were exposed at three predicted pressure levels: 5-, 7- and 15-psi (35-, 49- and 105-kPa). Two retrofitted S-280 shelters, mounted on 2½-ton trucks, and one fixed to the ground, were positioned at the predicted 5- and 7.3-psi (35- and 51.1-kPa) levels.

The truck-mounted shelters had equipment racks which were supported by shock-isolation systems. Simulated equipment were placed within the racks. The shelters were exposed at the pressure levels for which they were designed to survive, and in their most vulnerable orientation.

Instrumentation included pressure, displacement and acceleration gages. Peak-reading gages were used to measure peak displacements and accelerations. Displacement gages were used on the walls of one shelter and on the ground to obtain data for detailed comparisons with predictions of wall response. Two anthropomorphic dummies were placed within one shelter to obtain information on effects on personnel. The motion of the dummies was recorded by cameras within the shelters. Cameras were used to observe the exterior environment and response of the shelter and truck-shelter combinations.

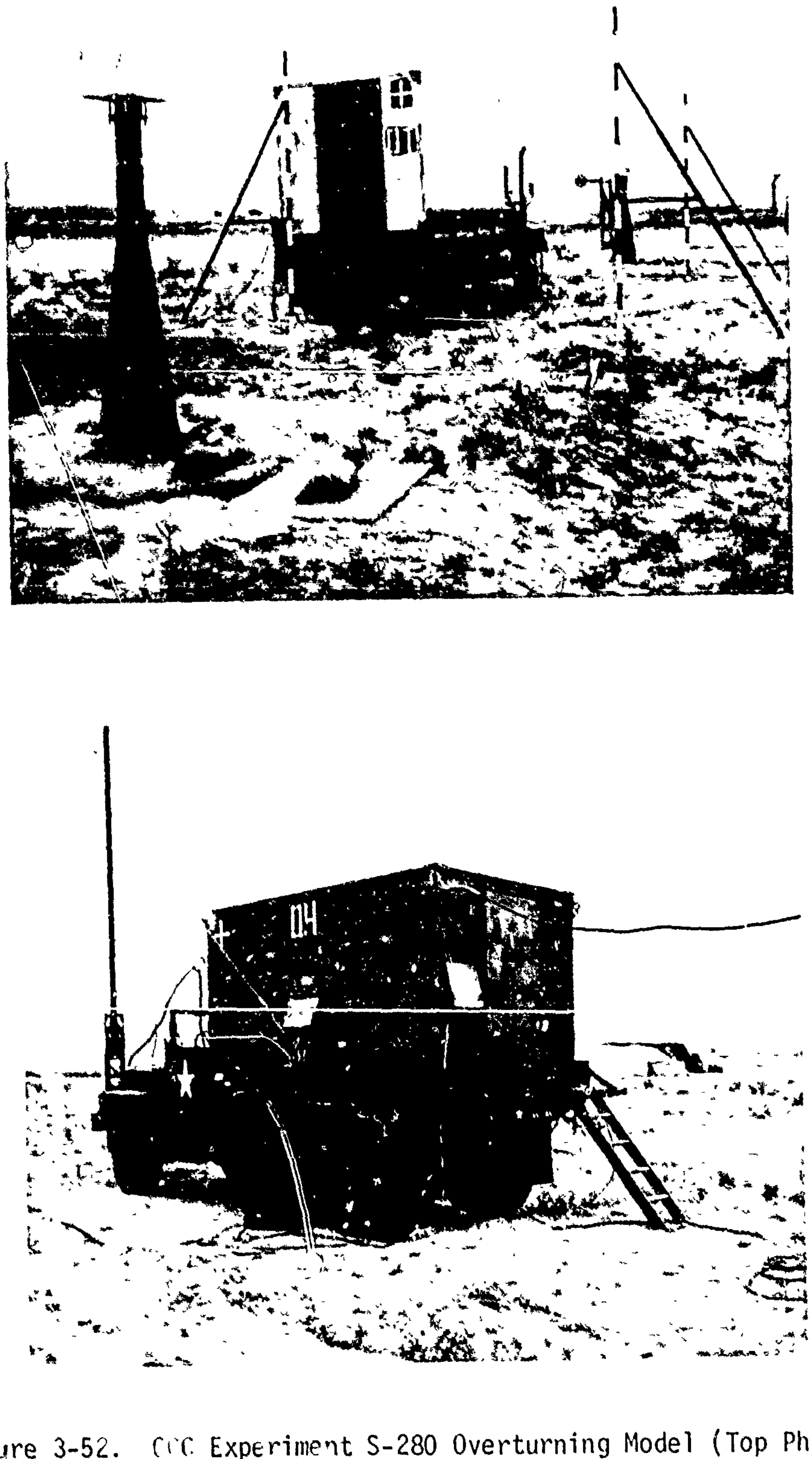
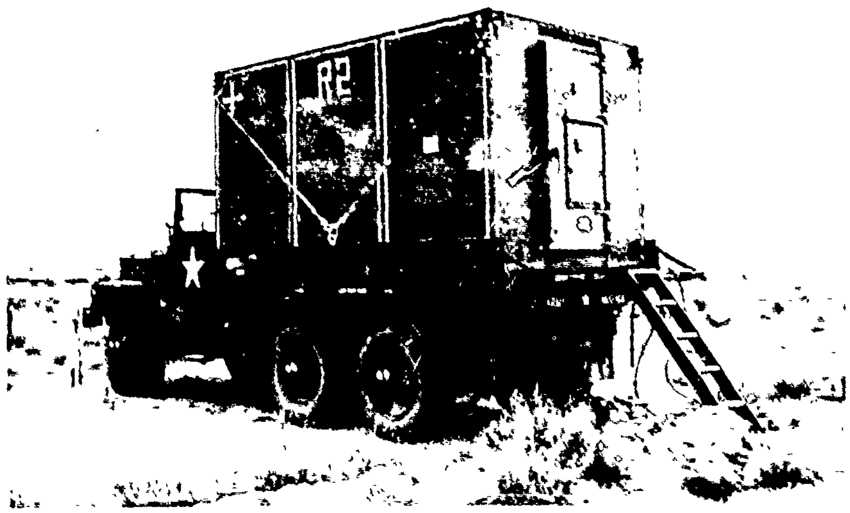


Figure 3-52. CCC Experiment S-280 Overturning Model (Top Photo) and S-280 Shelter (Bottom Photo), DICE THROW



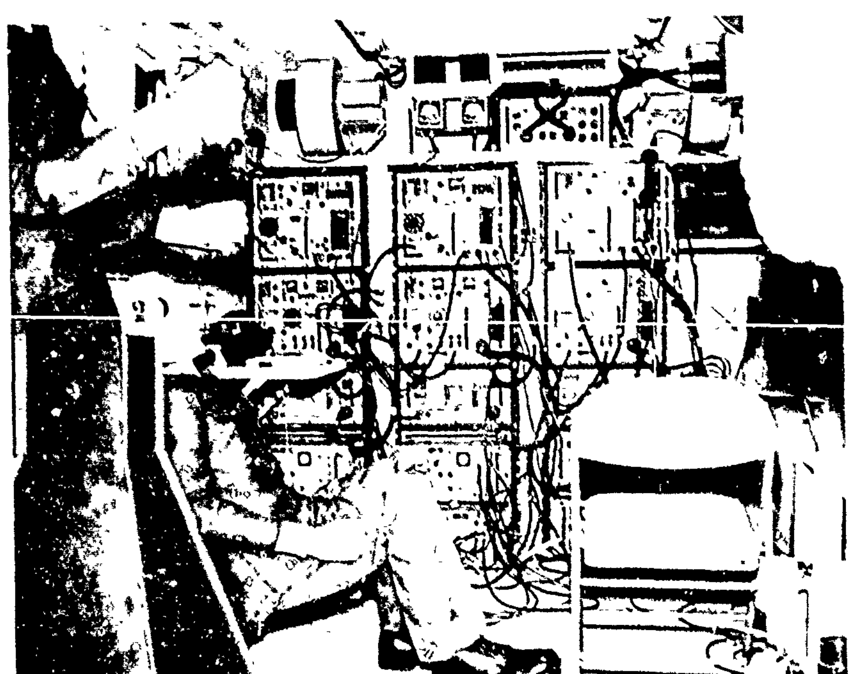


Figure 3-53. CCC Experiment Retrofit Shelter (Top Photo) and Internal View with Anthropomorphic Dummy (Bottom Photo), DICE THROW

7. BOEING Aerospace Corp.

TITLE: Industrial Equipment Survival/Recovery Feasibility Program

PROJECT OFFICERS: Mr. E. York and Mr. R. Holze

OBJECTIVE: Demonstrate the feasibility of achieving significant protection via earth arching under dynamic loads and determine what soil depth would be required to provide adequate arching.

EXPERIMENT DESCRIPTION: (Refer to Figure 3-54 for details on the overall experiment layout.) Several types of equipment were placed at 600, 200, 80 and 40 psi (4200, 1400, 560 and 280 kPa) locations. There were four large machines tested: a minibike at 600 psi (4200 kPa), an exactomatic drill grinder at 200 psi (1400 kPa), an electrolytic chip breaker grinder at 80 psi (560 kPa) and the power supply for the electrolytic chip breaker grinder at 40 psi (280 kPa). Other equipment included: 16 aluminum 6-in. (15.2-cm) diameter pipes of three different wall thicknesses at 600 psi (4200 kPa); 6 electric chain hoists to represent rugged machines; four varidrives and a vacuum pump to represent medium hard machines, 22 mechanical/electrical desk calculators and adding machines to represent soft machines; and five water-filled electronic cabinet racks to represent chemical tanks from chemical processing lines.

Most test specimens were placed on a foundation of rigid polystyrene foam. Either flexible polyurethane or aluminum chips were placed under some specimens to represent the placement of final protective material to fill voids in the machine support stand or legs. Refer to Figures 3-55 and 3-56 showing equipment packing and trenches used for equipment placement.

All machines were surrounded on all sides and on top by a layer of aluminum chips. Most of the specimens were placed at depths where arching of the soil above the protective material was expected to provide protection from the blast

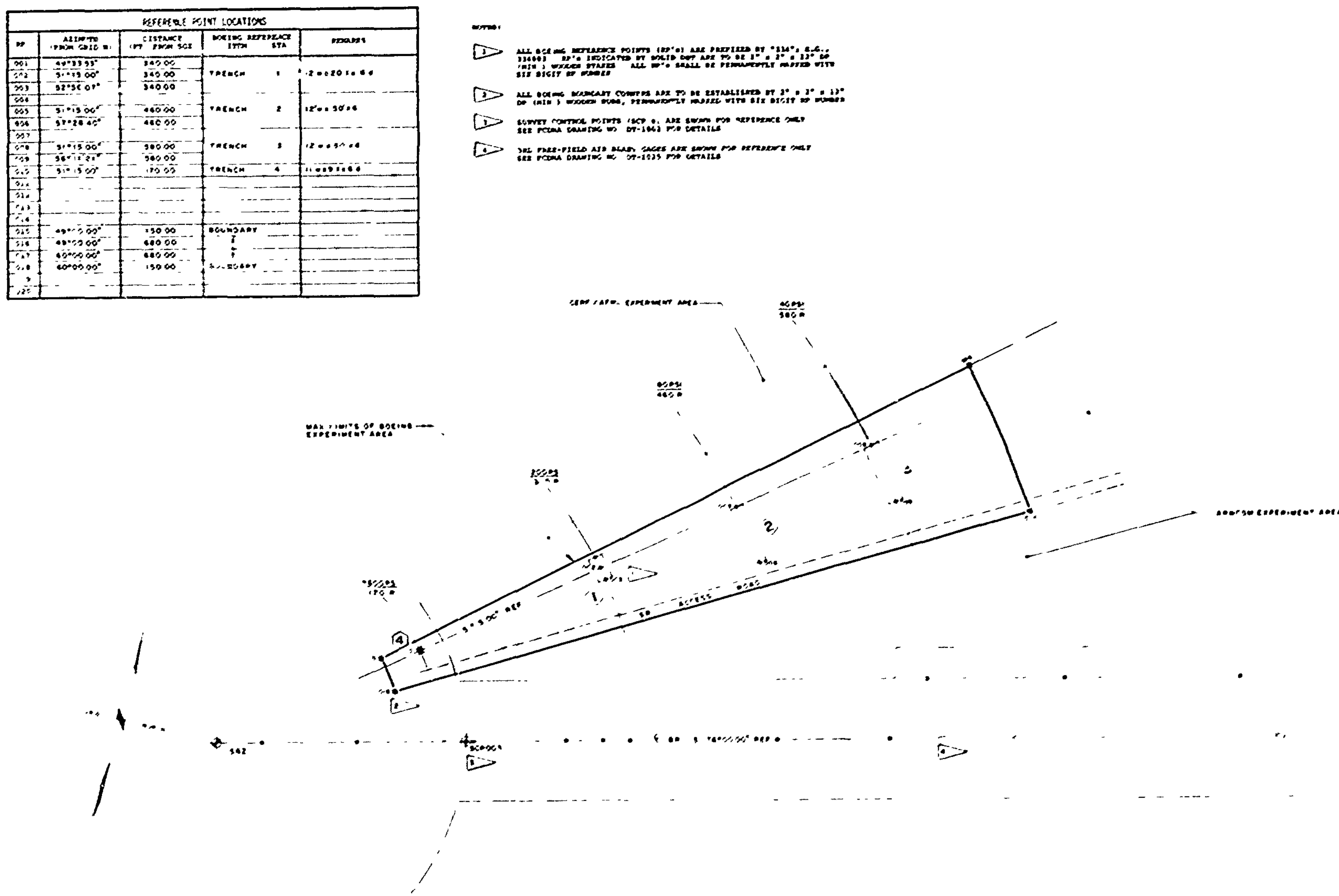


Figure 3-54. Boeing Industrial Equipment Experiment Layout, DICE THROW

Figure 3-55. Boeing Experiment Indicating Equipment Packing and Placement, DICE THROW

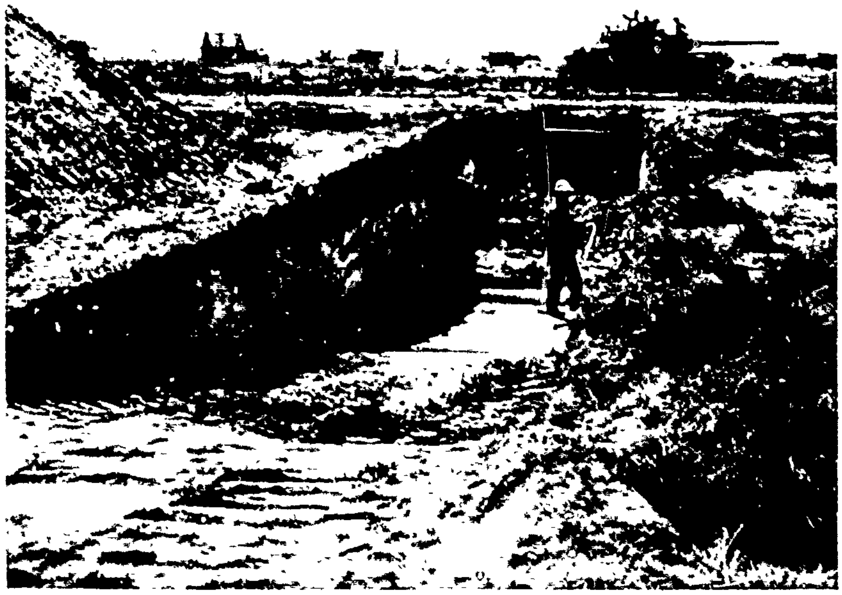


Figure 3-56. Boeing Industrial Equipment Trench, DICE THROW

wave. However, at the 200-psi (1400-kPa) station, a set of mechanical/electrical calculators were placed on 1-ft (0.30-m) increments at depths from 5 ft (1.5 m) to only 1 ft (0.30 m) to assure damage to some specimens and hopefully to determine the minimum depth of cover necessary to assure effective soil arching.

8. Canada/Defence Research Establishment Suffield (DRES)

   TITLE: Blast Response of Navy Masts, DNA Project #166

   PROJECT OFFICERS: Mr. J. Watson and Mr. F. Winfield (403) 544-3701, ext. 285

   OBJECTIVE: Determine the blast response of Navy masts and antennas. Refer to Figures 3-57 and 3-58 for an overall view of this project.

   EXPERIMENT DESCRIPTION: (1) Blast Response of Navy Masts (Refer to Figure 3-59.) A 30-ft (9.14-m) lattice-type mast, designed by computer, mounted on a 26x13x3-ft (7.9x3.96x0.9-m) concrete base was located at the predicted 10-psi (70-kPa) location. Instrumentation included

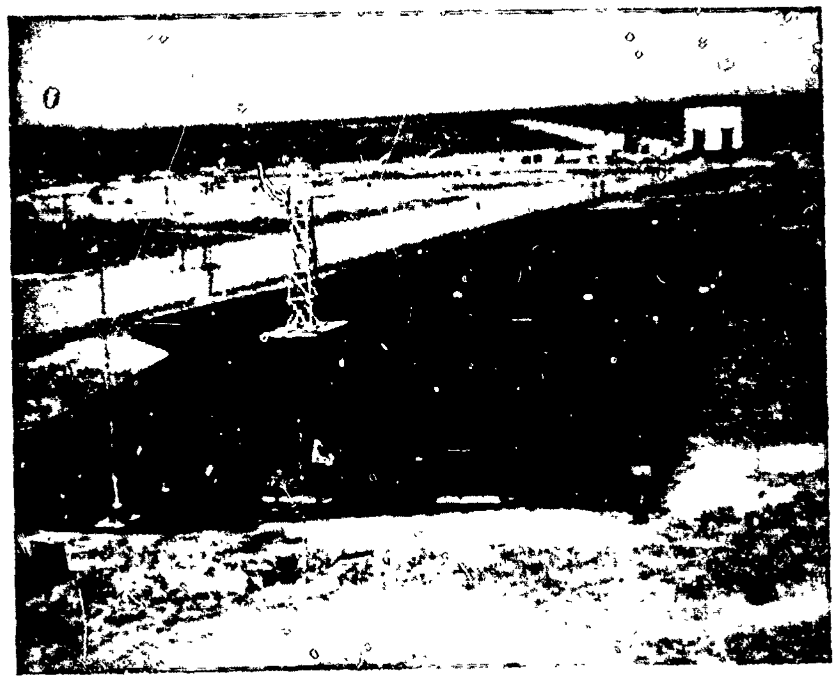


Figure 3-57. DRES Experiment Overviews, DICE THROW

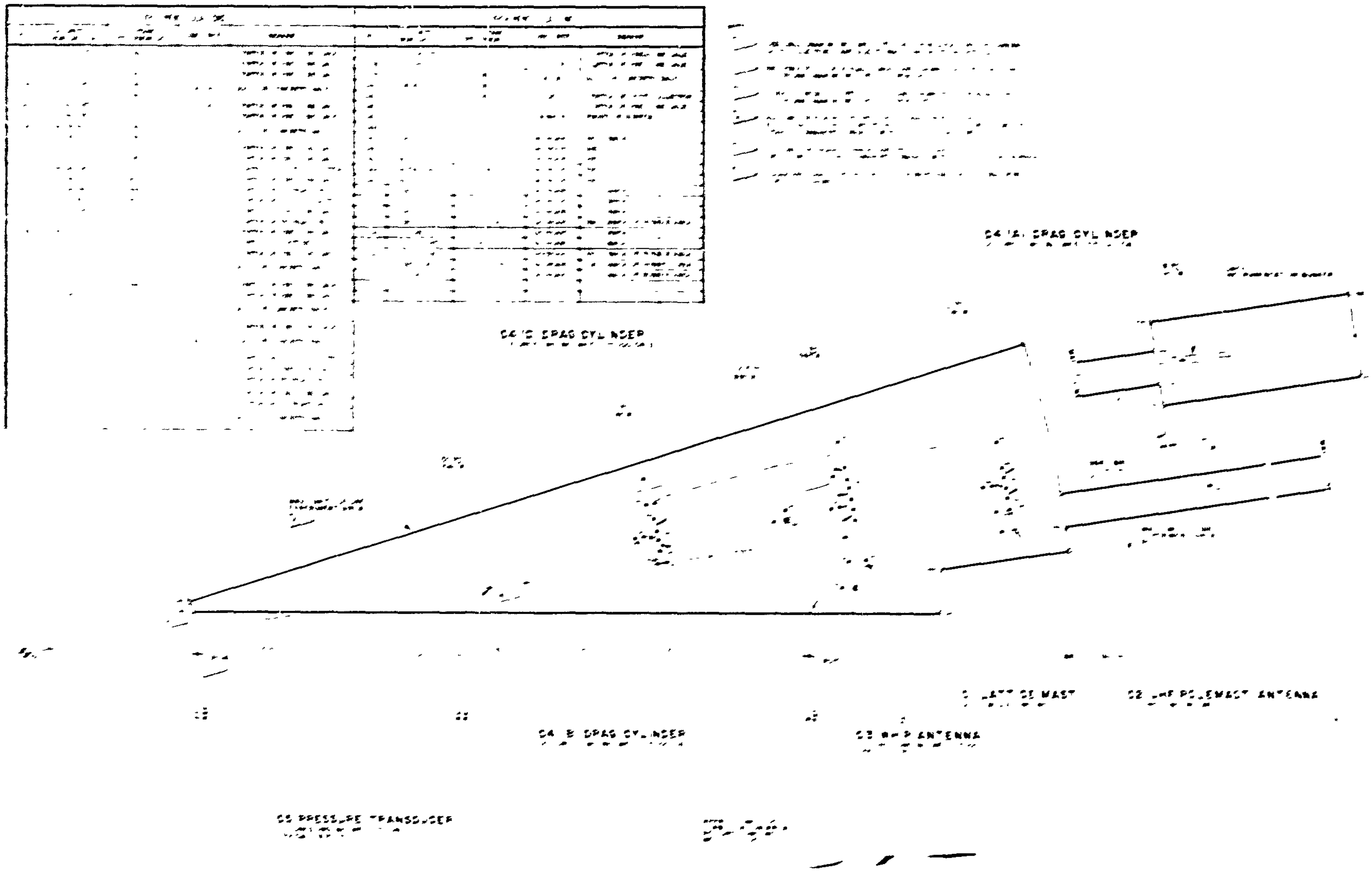


Figure 3-58. DPES Experiment Layout, DICE THROW

Figure 3-59. DRES Navy Mast Experiment - Footing for Mast Under Construction (Top Photo), Completed System (Bottom Photo), DICE THROW

36 channels recording strain, eight bending strains, three acceleration and one high-spee camera.

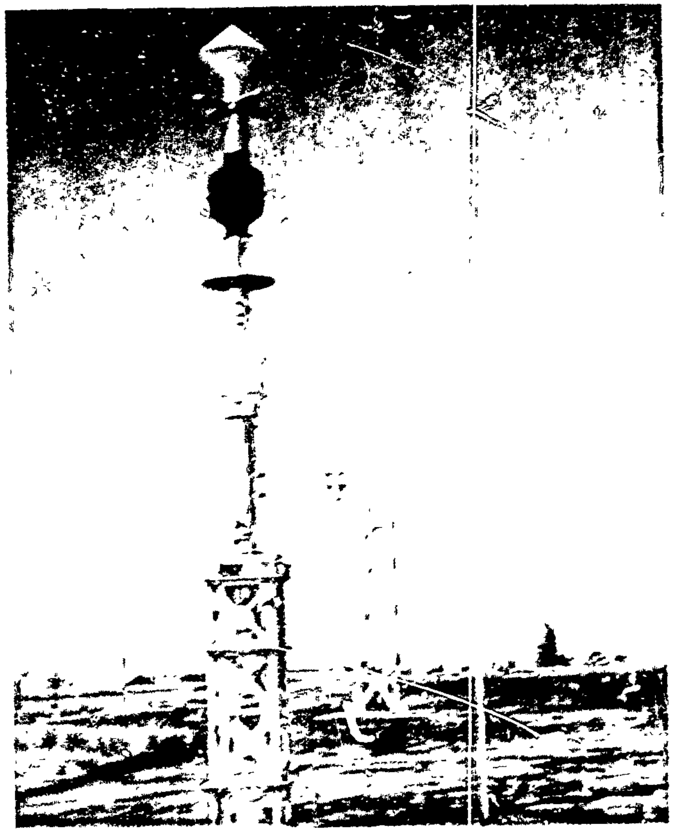
(2) Blast Response of the UHF Polemast Antenna. (Refer to Figure 3-60.) A newly developed UHF polemast antenna was placed at the 7-psi (49-kPa) incident overpressure level. The mast was 30 feet (9.14 m) high and was mounted on a 12 x 6 x 1-1/2-foot (3.7 x 1.8 x 0.46-m) reinforced concrete base. Instrumentation consisted of 10 channels recording structural response (strain), overpressure transducers, and high-speed photography. Note the dust collector.*

(3) Blast Response of 35-foot (10.7-m) Fiberglass Whip Antenna. (Refer to Figure 3-60.) Three redesigned 35-foot (10.7-m) fiberglass whip antennas were placed at the 10-, 12.2-, and 7-psi (85.4-, 70- and 49-kPa) incident overpressure levels. Instrumentation consisted of strain plus overpressure transducers and high-speed photography.

(4) Aerodynamic Drag. (Refer to Figure 3-61.) Three sizes of cylinders were used to measure the aerodynamic drag: 3.5-, 9- and 18-in. (8.9-, 22.9- and 45.7-cm). The 9- and 18-in.-(22.9- and 45.7-cm)-diameter circular cylinders will provide an almost complete spectrum of drag loading on cylinders. The 3.5-in. (8.9-cm) cylinder will provide experimental results for correlation to actual members of model masts. Cylinders were exposed at 20-psi (140-kPa), 10-psi (70-kPa) and 7-psi (49-kPa) locations. Instrumentation consisted of 12 channels of velocity data plus overpressure and high-speed photography.

(5) Airblast Measurements. A total of 14 Bytrex Model HFH-100 strain-type pressure transducers were installed. Fifteen transducers were located ahead of, or in the vicinity of, the structural response targets and the aerodynamic drag experiments to define their blast environment. One transducer was installed at each of the

*Next to the antenna. Fifteen dust collectors were placed adjacent to the drag cylinders. (See (4) below.) This was to assess the augmentation of drag force within 6.5 feet (2 m) of the ground.



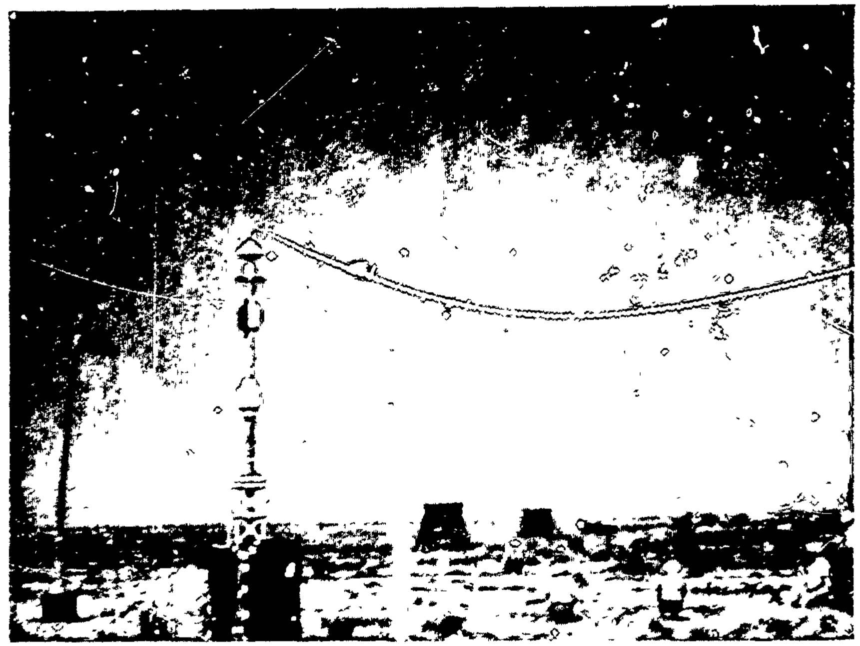


Figure 3-60. DPEC UHF Polemast Antenna (Left Photo), and Fiberglass Whip Antenna During "Twang" Test Calibration, (Right Photo), DICE THROW

Figure 3-61. DRES Drag Cylinder Mounts and Whip Antenna in Background, DICE THROW

50-psi (350-kPa) and 5-psi (35-kPa) locations to extend the range over which pressure-distance data would be obtained. At the 20-, 10- and 7-psi (140-, 70- and 49-kPa) levels, transducers were set out so that two transducers were on a radial line through ground zero. The time of arrival of the shockwave at the successive gages would be used to calculate shock front velocity from which peak overpressure could be calculated for comparison with the results obtained from individual transducers.

9. CHRYSLER

TITLE: Gunner's Primary Sight (GPS) and Crosswind Sensor

PROJECT OFFICER: Mr. Smith

OBJECTIVE: Verify prediction mode during the XM1 Validation Phase as to responses of the subsystem and their components to simulated nuclear blast loading.

EXPERIMENT DESCRIPTION: The Gunner's Primary Sight (GPS) and Crosswind Sensor were placed at the predicted 10-psi (70-kPa) overpressure level. These devices were mounted in and upon the ballistic test stand. (Refer to Figure 3-62). The base was made of reinforced concrete and was designed to prevent gross movement of the experiment by the blast wave drag loading. (Refer to Figure 3-63 for the experiment layout details.)

10. Denver Research Institute (DRI)

TITLE: Technical Photography, DNA Project #921

PROJECT OFFICER: Mr. J. Wisotski, (303) 753-2616 or -2782

OBJECTIVES: Perform and analyze ground level technical motion photography and analyze overhead and ground level photography to identify the fireball and shock environment characteristics from a 628-ton (570-metric-ton) ANFO detonation.

EXPERIMENT DESCRIPTION: DRI was responsible for the technical photography of the detonation phenomena from DICE THROW

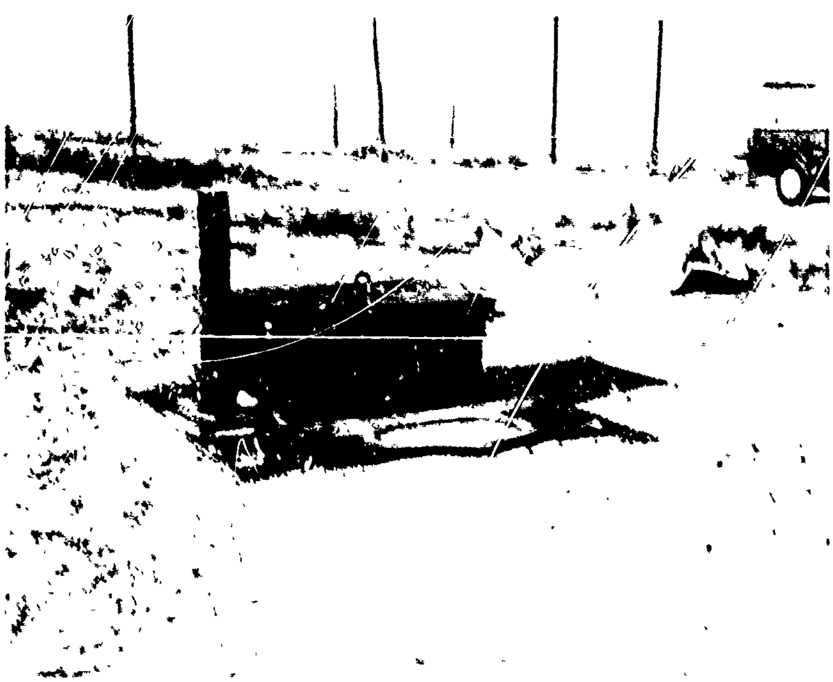


Figure 3-62. CHRYSLER Gunner's Primary Sight (GPS) and Crosswind Sensor, DICE THROW

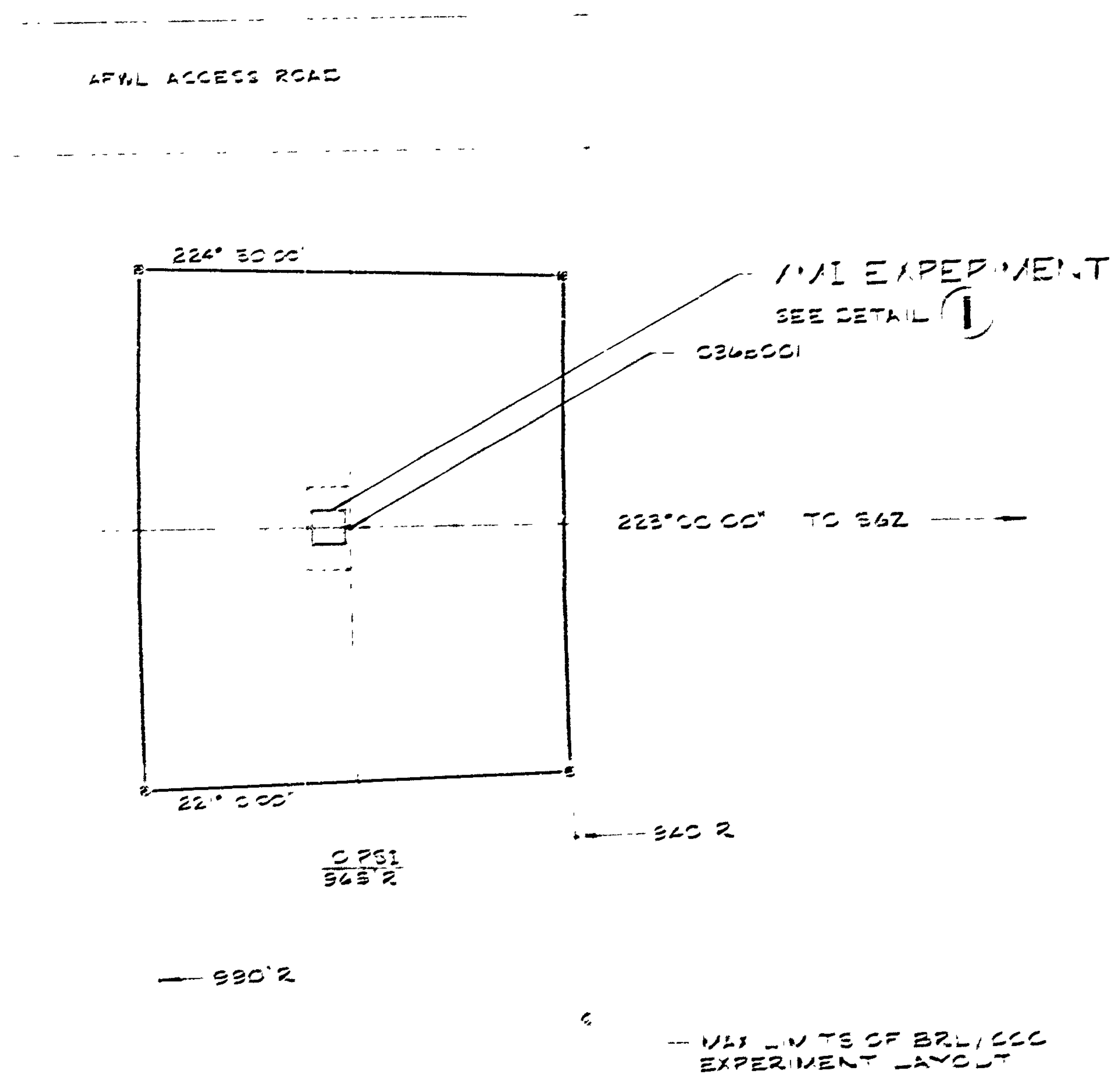


Figure 3-63. Chrysler Experiment Layout, DICE THROW

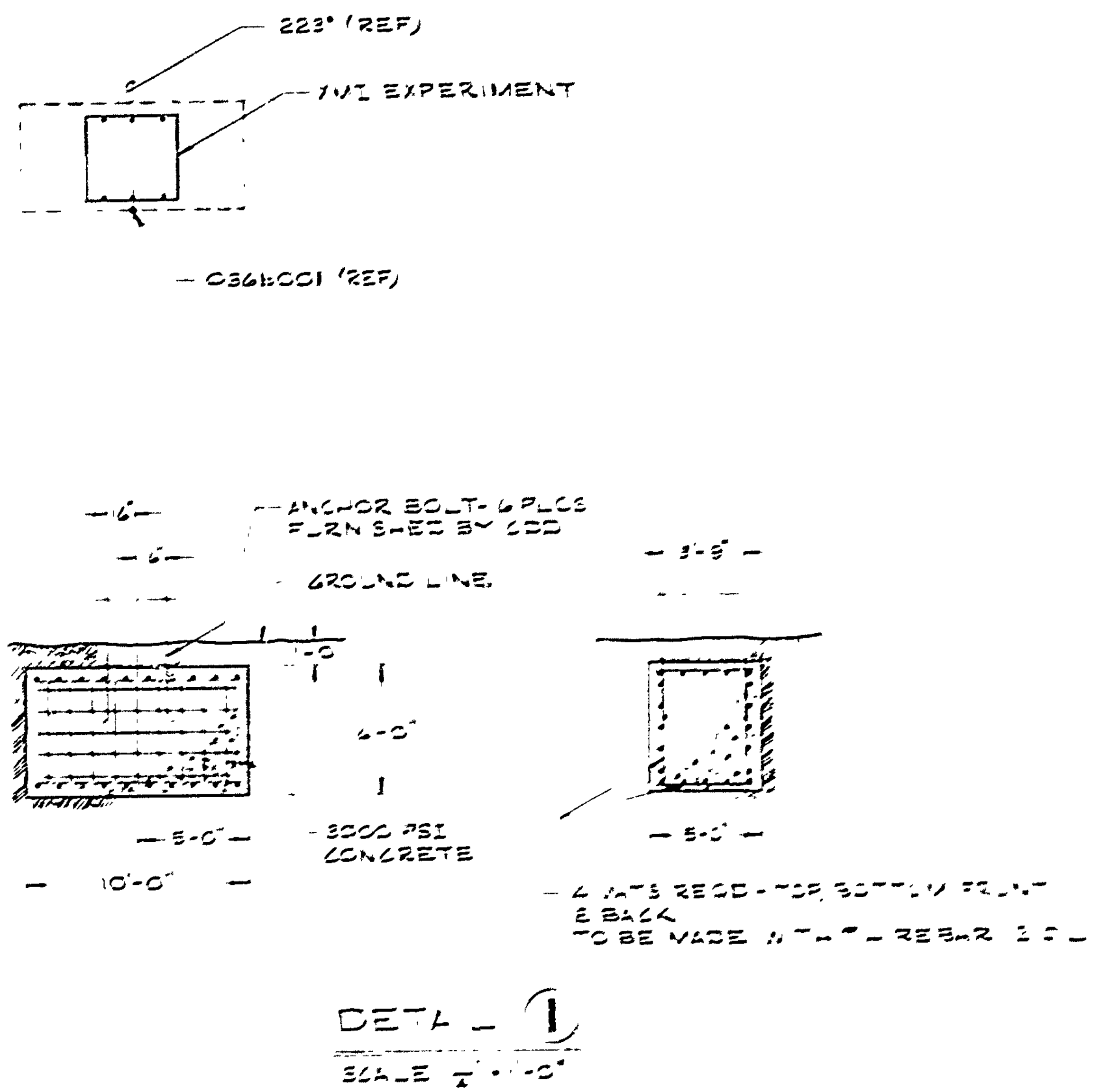


Figure 3-63. Chrysler Experiment Layout, DICE THROW (Continued)

and also the technical photography of different targets in the U. S. Army and FRG Wall Structure experiment programs, which were under the direction of the Ballistic Research Laboratory (BRL) and Stanford Research Institute (SRI), respectively.

A total of 28 cameras and 4 photometric devices were employed at four locations in the DRI technical photography program. The BRL technical photography utilized 78 cameras situated in seven project locations.

The DRI camera locations were about 4500 ft (1371.6 m) from surface ground zero (SGZ) and were situated radially approximately west (1), south (2), southeast (3) and east (4) around SGZ (refer to Figure 3-64). There were three cameras each at the west and southeast stations. There were 13 cameras and three photometric devices at the main camera station (2). There were nine cameras situated in the east camera station. Table 3-11 gives a listing of the cameras and photometric devices used in the photography of the detonation phenomena.

There were 12 channels of photometric data. Two of these channels were used to obtain the average detonation velocity through the charge. The other ten were used to obtain the temperature-time, unit radiation and total radiation data.

The DRI technical photography was divided among seven projects which utilized 78 cameras (refer to Figure 3-65 showing camera mounts). The project description and the number of cameras employed during the event are as indicated in Table 3-12.

11. Stanford Research Institute (SRI)

TITLE: Wall Experiment, DNA Project #337

PROJECT OFFICER: Mr. C. Wiehle (415) 326-6200

OBJECTIVE: Investigate the dynamic response and collapse modes for two types of German house construction subjected to air blast loading; the two types were masonry cavity wall and Fachwerk, or half-timber construction. The data from this experiment are of direct interest to the development of the DNA collateral damage methodology.

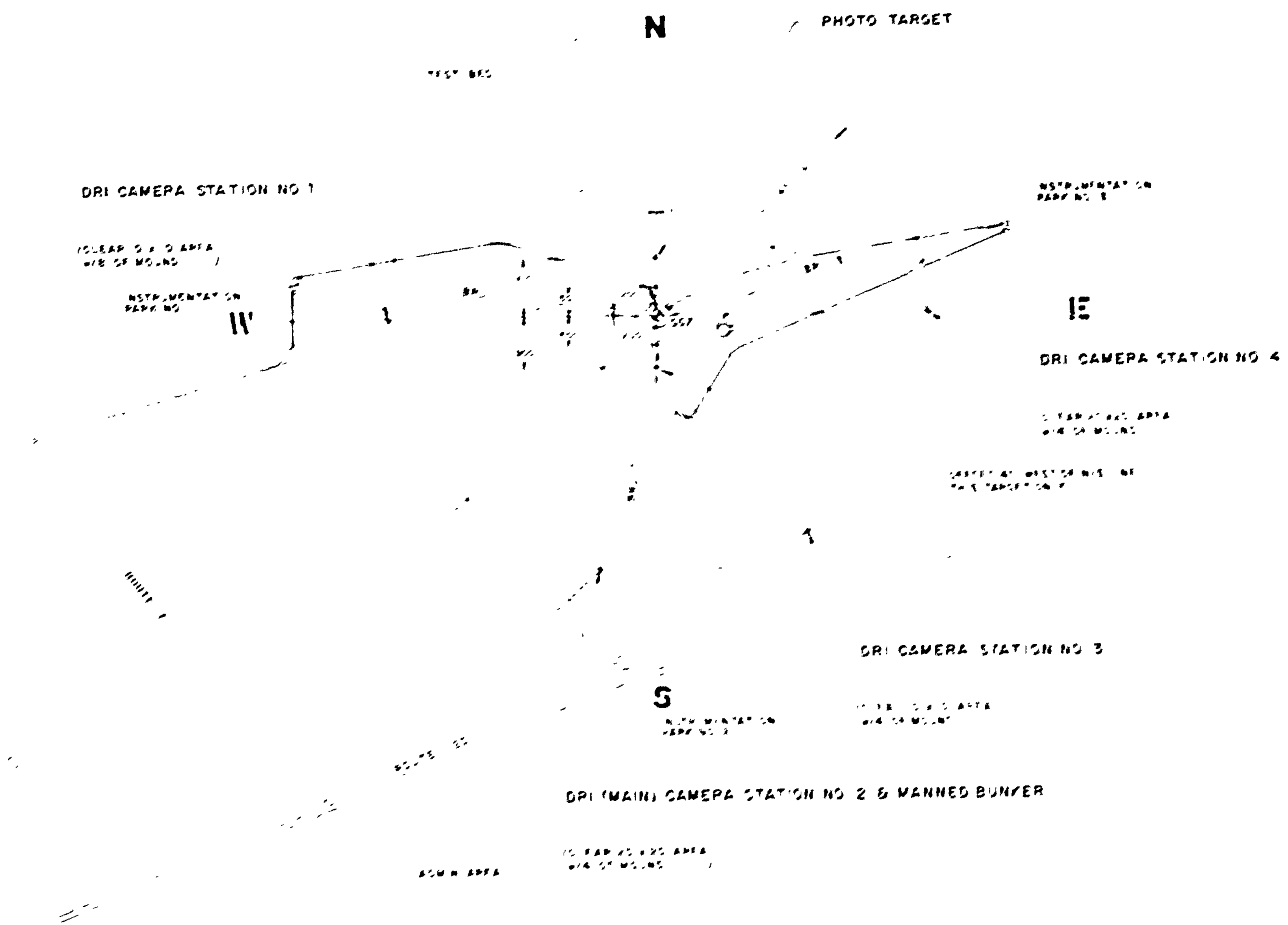


Figure 3-64. DRI Camera Stations, DICE THROW

Table 3-11. DRI Camera Details, DICE THROW

Camera Type	Location and Designation	Framing Rate/Film (frames/sec)	Lens (mm)	View*
Fastax	DRI-1 (West)	4,500 EF	50	Shockwave Breakout (1)
Fastax	DRI-1	4,500 EF	50	Shockwave Breakout (2)
DB Milliken	DRI-1	250 EF	25	Cloud Cover/Fireball
Fastax	DRI-2 (Main-South)	4,500 EF	50	Shockwave Breakout (1)
Nova	DRI-2	4,500 EF	50	Shockwave Breakout (2)
Locam	DRI-2	500 EF	18	Cloud Cover/Fireball
Hycam 1	DRI-2	24,000 EIR	50	Fireball
Hycam 2	DRI-2 (Lost Processing)	6,000 (Infrared B&W)	35	Fireball
Hycam 3	DRI-2 (Lost Processing)	6,000 (Infrared B&W)	25	Fireball
Hulcher 1	DRI-2	20 EF	150	Fireball/Cloud Ejecta
Hulcher 2	DRI-2	20 SB	150	Fireball/Cloud Ejecta
Hulcher 3	DRI-2	20 SB	150	Fireball/Cloud Ejecta (1)
Hulcher 4	DRI-2	20 SB	150	Fireball/Cloud Ejecta (2)
DB Milliken	DRI-2	128	10	Cloud Cover/Fireball
Dynafax	DRI-2 (Direct Readout)	26,000	240	Fireball
Dynafax	DRI-2 (Direct Readout)	26,000	150	Fireball
Optical Pyrometer (Py I)	DRI-2	Risetime ≈3 μsec 3 channels	240	Temperature-Time
Modified (Py I)	DRI-2	Risetime ≈3 μsec Unit Radiation	240	Unit Radiation-Time
Solar Cell	DRI-2	Risetime ≈3 μsec Total Radiation	—	Total Radiation-Time
Spectrograph	DRI-2	Time-Integrated SB		Spectra 300 nm to 700 nm
Fastax	DRI-3 (Southeast)	4,500 EF	50	Shockwave Breakout (1)
Fastax	DRI-3	4,500 EF	50	Shockwave Breakout (2)
DB Milliken	DRI-3 (Out of Focus)	200 EF	17	Cloud Cover/Fireball
Fastax	DRI-4 (East)	4,500 EF	50	Shockwave Breakout (1)
Fastax	DRI-4	4,500 EF	50	Shockwave Breakout (2)
DB Milliken	DRI-4	400 EF	16	Cloud Cover/Fireball

*(1) left of SGZ; (2) right of SGZ, Ektachrome (EF); Linagraph Shellburst (SB); Ektachrome Infrared (EIR).

Table 3-11. DRI Camera Details, DICE THROW (Continued)

Camera Type	Location and Designation	Framing Rate/Film (frames/sec)	Lens (mm)	*View
Hulcher 1	DRI-4	20 SB	240	500-1000-ft Left Ejecta/Fireball
Hulcher 2	DRI-4	20 SB	240	Charge Left 500-ft Ejecta/Fireball
Hulcher 3	DRI-4	20 SB	240	Charge Right Ejecta/Fireball
Hulcher 4	DRI-4	20 SB	240	500-1000-ft Right Ejecta/Fireball
Hulcher 5	DRI-4	20 SB	150	Charge Left Ejecta/Fireball
Hulcher 6	DRI-4	20 SB	150	Charge Right Ejecta/Fireball
DB Milliken	Helicopter*, HCC6	400	16	Internal-Boom Section 1.8 psi
DB Milliken	Helicopter*, HCC5	400	10	Pilot-Control Panel 1.8 psi
DB Milliken	Helicopter, HCC4	400	25	Inflight-Helicopter Control Bunker 1.8 psi
DB Milliken	Helicopter, HCC3	400	25	Inflight-Helicopter Observer Bunker 1.8 psi
Photosonic	Helicopter, HCC2	1,000	13	Stationary Helicopter 3.5 psi
Hulcher	Helicopter, HCC7	20	150	Inflight Helicopter 1.8 psi
Photosonic	Helicopter, HCC1	1,000	13	Stationary Helicopter 3.5 psi
DB Milliken	Oak Ridge Shelter*, OLC1	400	13	Internal Two Dummies - Russian Bunker 25 psi
Photosonic	C^3, C^3C20	1,000	25	TT-2 4 psi
Nova	C^3, C^3C21	1,000	25	TT-3 4 psi
Photosonic	C^3, C^3C22	1,000	13	N/A1, N/A2 3 psi
Photosonic	C^3, C^3C23	1,000	13	C/B, J3 3 psi
Photosonic	C^3, C^3C24	1,000	13	06 3 psi
Photosonic	C^3, C^3C25	1,000	13	07, 08 3 psi
Locam	C^3, C^3C26*	400	13	Internal (07) Two Dummies 3 psi
Photosonic	C^3, C^3C27	1,000	13	07, 08 3 psi
Photosonic	C^3, C^3C1	1,000	13	OT (Back) 15 psi
Photosonic	C^3, C^3C2	1,000	13	OT (Front) 15 psi
Nova	C^3, C^3C3	1,000	13	HA1, 2 & 3 (Side) 7.3 psi
Nova	C^3, C^3C4	1,000	5	HA1, 2 & 3 (Front) 7.3 psi
Nova	C^3, C^3C5 (Lost)	1,000	13	S1 (Angle) 7.3 psi
Nova	C^3, C^3C6	1,000	13	S1 (Side) 7.3 psi
Nova	C^3, C^3C7	1,000	13	01 7.3 psi

Table 3-11. DRI Camera Details, DICE THROW (Continued)

Camera Type	Location and Designation	Framing Rate (frames/sec)	Lens (mm)	View
Photosonic	C^3, C^3C8	1,000	13	02 7.3 psi
Nova	C^3, C^3C9	1,000	13	J1, R1 7.3 psi
Locam	C^3, C^3C10*	400	13	Internal (R1) Two Dummies 7.3 psi
Nova	C^3, C^3C11	1,000	25	Mod 7.3 psi
Nova	C^3, C^3C12	1,000	13	HA4, 5, 6 (Side) 5.0 psi
Photosonic	C^3, C^3C13	1,000	5	HA4, 5, 6 (Front) 5.0 psi
Photosonic	C^3, C^3C14	1,000	13	TT-1, J2 5.0 psi
Photosonic	C^3, C^3C15	1,000	13	03 5.0 psi
Locam	C^3, C^3C16*	400	13	Internal (04) Two Dummies 5.0 psi
Photosonic	C^3, C^3C17	1,000	13	04 5 psi
Photosonic	C^3, C^3C18	1,000	13	04 (Angle) 5 psi
Nova	C^3, C^3C19 (Lost)	1,000	25	P2 5 psi
Locam	Wheeled Vehicles, WVC1	400	13	2-1/2-ton 20 psi
Locam	Wheeled Vehicles, WVC2	400	13	2-1/2-ton 20 psi
Locam	Wheeled Vehicles, WVC3	400	13	2-1/2-ton 20 psi
Locam	Wheeled Vehicles, WVC4	400	13	2-1/2-ton 20 psi
Locam	Wheeled Vehicles, WVC5	400	13	Jeep 20 psi
Locam	Wheeled Vehicles, WVC6	400	13	Jeep 20 psi
Locam	Wheeled Vehicles, WVC7	400	13	2-1/2-ton 14 psi
Locam	Wheeled Vehicles, WVC8	400	13	2-1/2-ton 14 psi
Locam	Wheeled Vehicles, WVC9	400	13	2-1/2-ton 14 psi
Locam	Wheeled Vehicles, WVC10	400	13	2-1/2-ton 14 psi
Locam	Wheeled Vehicles, WVC11	400	13	Jeep 14 psi
Locam	Wheeled Vehicles, WVC12	400	13	Jeep 14 psi
Locam	Lovelace, LSC1*	400	10	Fighting Bunker 25 psi Face On - Two Dummies
Locam	Lovelace, LSC2*	400	10	Fighting Bunker 15 psi Face On - Two Dummies
Locam	Lovelace, LSC3*	400	10	Fighting Bunker 15 psi Side On - Two Dummies
Nova	ARMCOM, WSC1 (Lost)	1,000	100	M60 - 40 psi
CB Milliken	ARMCOM, WSC2* (Lost)	1,000	10	M60 Internal 40 psi Two Dummies

Table 3-11. DRI Camera Details, DICE THROW (Continued)

Camera Type	Location and Designation	Framing Rate (frames/sec)	Lens (mm)	*View
Photosonic	ARMCOM, WSC3	1,000	13	M551 - 15 psi
DB Milliken	ARMCOM, WSC4*	400	5	M551 Internal 15 psi
Photosonic	ARMCOM, WSC5	1,000	13	M109 - Dummy Outside 20 psi
DB Milliken	ARMCOM, WSC6*	400	5	M109 - Internal Two Dummies 20 psi
DB Milliken	ARMCOM, WSC7*	400	20	Underground Three Dummies Command Post 20 psi
Photosonic	ARMCOM, WSC8	1,000	13	M551 - 15 psi
DB Milliken	ARMCOM, WSC9*	400	10	M551 Internal 15 psi Two Dummies
Photosonic	ARMCOM, WSC10	1,000	13	M557 - 10 psi
DB Milliken	ARMCOM, WSC11*	400	13	M557 Internal 10 psi Two Dummies
Photosonic	ARMCOM, WSC12	1,000	13	M110 10 psi
Photosonic	ARMCOM, WSC13	1,000	13	GLGP 8.4 psi
Photosonic	ARMCOM, WSC14	1,000	13	XM204 7.5 psi
Nova	ARMCOM, WSC15	1,000	13	M577 - Deployed 5 psi Three Dummies (Angle)
Nova	ARMCOM, WSC16	1,000	13	M537 - Deployed 5 psi Three Dummies (Front)
DB Milliken	ARMCOM, WSC17*	400	18	ARMCOM Recording (4.5 psi) Bunker (Internal)
Photosonic	ARMCOM, WSC18	1,000	25	M109 2.5 psi
Nova	ARMCOM, WSC19	1,000	25	XM198 2.5 psi Dummy
Photosonic	ARMCOM, WSC20	1,000	5	Overview 2.0 psi
Photosonic	Foreign Systems, WSC21	1,000	13	Dutch Vehicle 15 psi
DB Milliken	Foreign Systems, WSC22*	400	13	Dutch Vehicle 15 psi Three Dummies (Internal)
Nova	Wall Project, WAC1 (Lost)	1,000	13	Wall Project 7.3 psi Angle North
Nova	Wall Project, WAC2	1,000	13	Wall Project 7.3 psi Angle South
Photosonic	Wall Project, WAC3	1,000	25	Wall Project 3.5 psi Angle North
Photosonic	Wall Project, WAC4	1,000	25	Wall Project 3.5 psi Angle South
Photosonic	Wall Project, WAC5	1,000	25	Wall Project 2.0 psi Angle North
Photosonic	Wall Project, WAC6	1,000	25	Wall Project 2.0 psi Angle South

*Internal

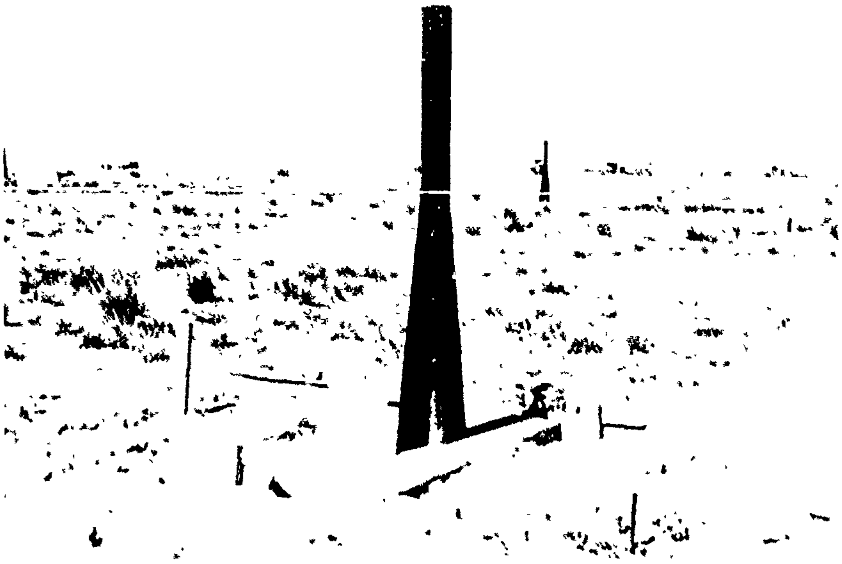


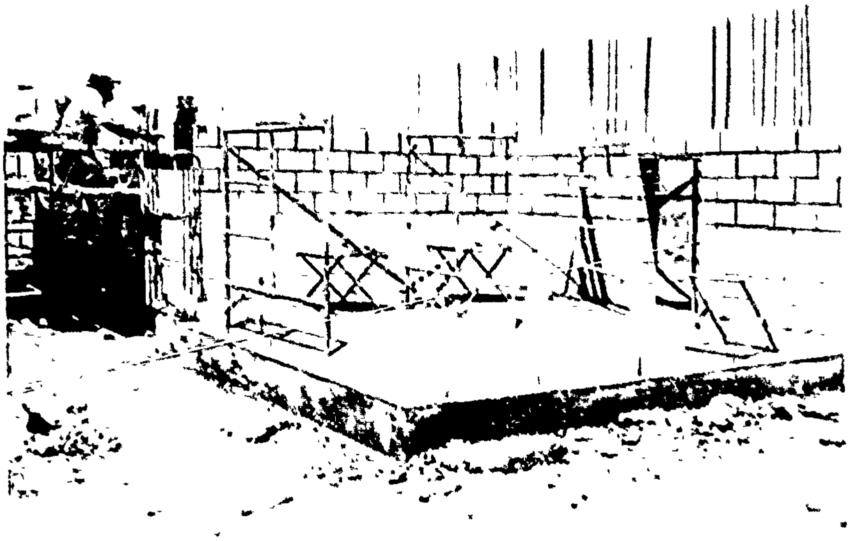
Figure 3-65. DRI Camera Mounts on DICE THROW

Table 3-12. Additional DRI Camera Stations Required for Agency Support

Project	Number Used
C^3 Shelters	27
ARMCOM	20
Wheeled Vehicles	12
Helicopter	7
Wall	6
Lovelace	3
Foreign	2
Oak Ridge	1
TOTAL	78

EXPERIMENT DESCRIPTION: The test structures constructed by Falcon, Inc., Socorro, New Mexico, were approximately 16 ft x 28 ft (4.9 m x 8.5 m) in plan dimensions and about 20 feet (6.1 m) high at the ridge. (Refer to Figures 3-66 and 3-67.) There were three identical structures, each located at a different range east of ground zero. Structure No. 1 was located at a range of 1140 feet (347.5 m), [7.0-psi (21-kPa) predicted free-field overpressure level]; Structure No. 2 at 1730 ft (527.3 m) [3.5-psi (24.5 kPa)]; and Structure No. 3 at 2750 ft (838.2 m) [2.0-psi (14-kPa)]. The front wall of the structures faced west. Refer to Figure 3-68 for the experiment layout.

Each structure consisted of two adjoining, but distinct test cells constructed on a common reinforced concrete slab cast on grade: one test cell was of masonry cavity wall construction and the other of Fachwerk, or half-timber construction. The masonry cavity wall test cell consisted of unreinforced brick and concrete masonry unit wall panels on the front and one side, and a reinforced concrete ceiling slab. The Fachwerk wall test cell consisted of brick and



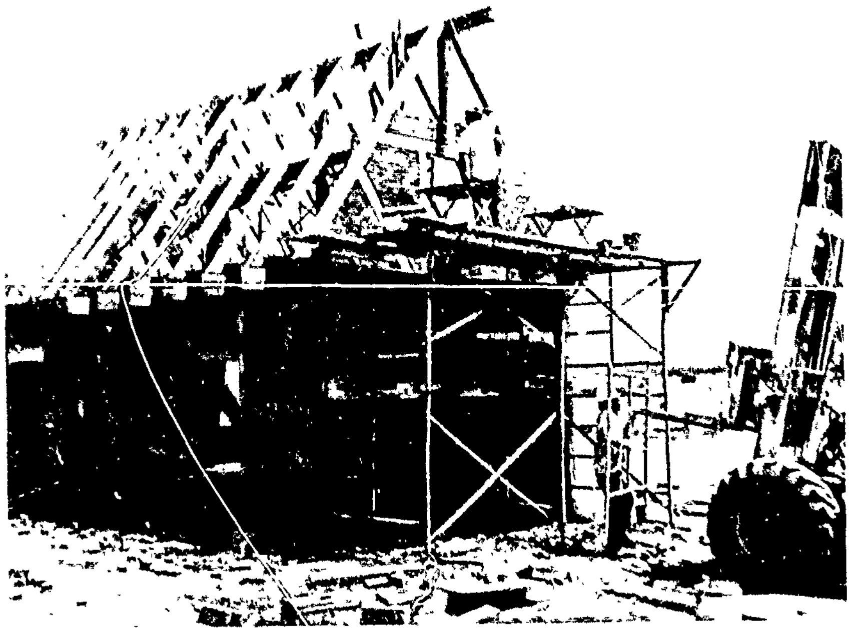


Figure 3-66. SRI German Structures Experiment During Construction, DICE THROW

Figure 3-67. SRI German Structures Experiment - Completed Structure (Top Photo), Transducers Inside Structure (Bottom Photo)

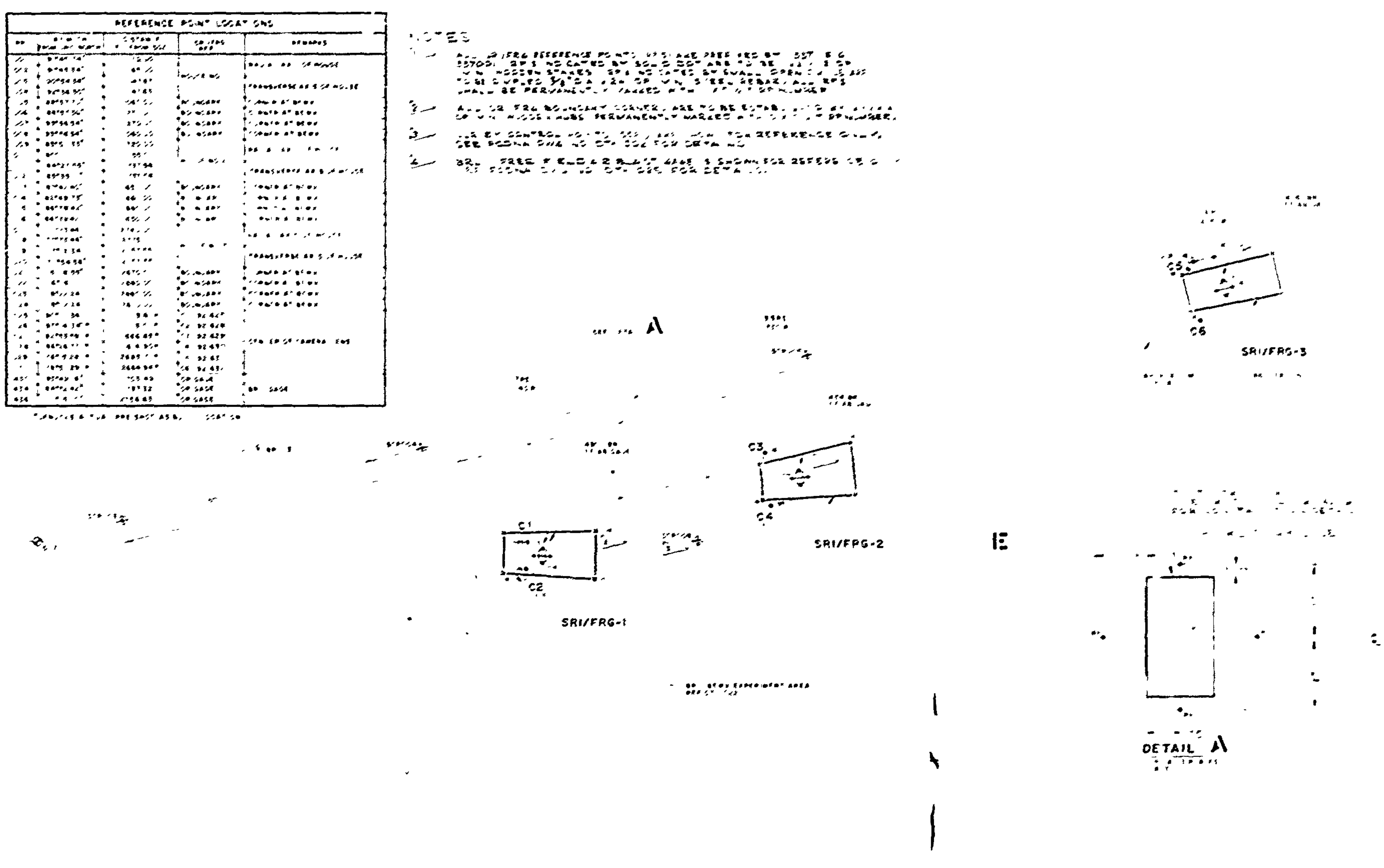


Figure 3-68. SRI Experiment Layout, DICE THROW

timber wall panels on the front and one side, and a timber joist ceiling system. The back wall of the test structure and an interior wall separating the two test cells were constructed of reinforced concrete masonry units. The test structures were covered by a wood-frame gable-roof system supporting heavy clay tile roofing.

The selection of the walls to be included in the field test was based on typical types of West German house construction for which no dynamic response and collapse information was available. One wall type selected was representative of masonry cavity wall construction found in load-bearing wall residences of relatively recent periods, and the other wall type was representative of the traditional Fachwerk (half-timber) construction prevalent throughout Germany during previous periods.

The instrumentation for the three test structures included 35 electronic gages, consisting of 26 pressure and 9 deflection gages, and 6 high-speed cameras. The electronic gages consisted of exterior pressure gages to measure the pressure-time history of the front and side test walls; interior pressure gages to measure the pressure transients and the room-pressure build-up for determining the differential pressure-time loading on the test-wall panels; pressure gages to measure the pressure-time on the upper and lower surfaces of the second-story (ceiling) concrete slab to determine if a significant pressure differential existed on the slab; and deflection gages to measure the dynamic response of selected wall panels. These measurements were installed and recorded by BRL. The photographic coverage was provided by DRI.

All structures were instrumented identically, except that Structure No. 3 (at 2.0 psi (14 kPa)) had two additional head-on pressure gages located in the front face of the reinforced concrete pilaster that separates the masonry cavity and

Fachwerk test walls. The purpose of the additional pressure gages was to determine if any pressure anomalies occurred on the exterior surface of the front wall as a result of the 1-ft (0.30-m) overhang of the second-story floor systems.

Two high-speed cameras were installed at each structure location. The cameras were located north and south of each structure at an angle of 50 degrees from the front wall, and their primary purpose was to record the mode of response and collapse mechanism of each wall element, including individual Fachwerk panels. The cameras were to supplement the electronic gage measurements, and to assist in the post-shot analysis by providing a visual record of the initia' and final wall break-up and debris transport.

12. Federal Republic of Germany (FRG)/U. S. Army Engineer Waterways Experiment Station (WES)

TITLE: FRG Structures Test, DNA Project #157

PROJECT OFFICER: Dr. J. Balsara/WES, (601) 636-3111, ext. 2750.

OBJECTIVES: The objectives of the FRG program are to provide information on the loading and response of above-ground, surface flush, and buried structures; provide experimental data to verify analytical and design procedures; and identify the instructure shock environment.

EXPERIMENT DESCRIPTION: Refer to Figures 3-69 through 3-71 for views of the test items during the construction phase and after completion. The program included the testing of 12 structures representing six designs. Duplicate structures were placed at different ranges from ground zero in an attempt to incur structural response at the design level and at a level where moderate damage would be observed. The test structures consisted of six models of a rectangular shear-wall design with an interior floor and wall, two full-scale prefabricated modular concrete personnel shelters (refer to Figure 3-72), two full-scale prefabricated corrugated-metal

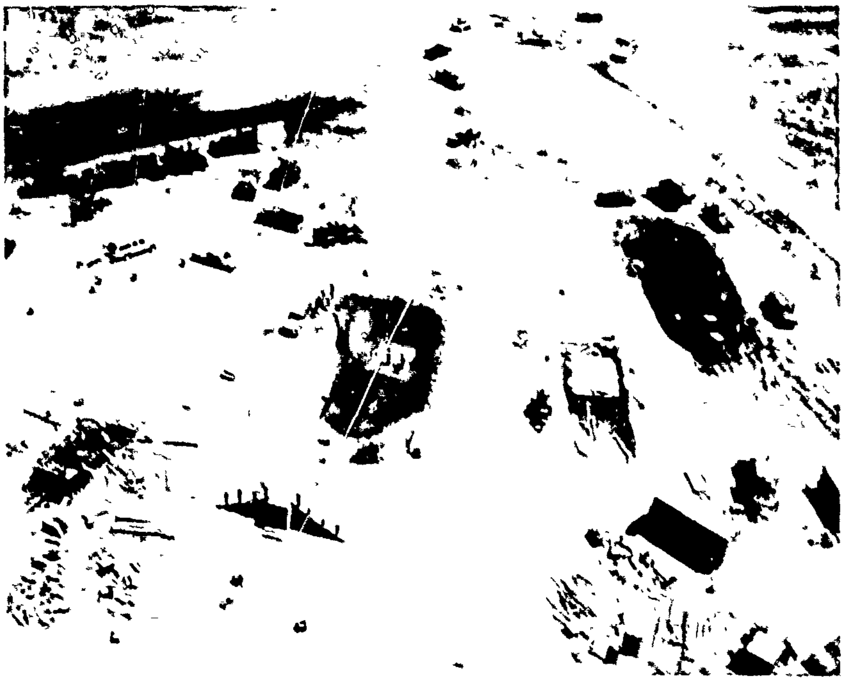
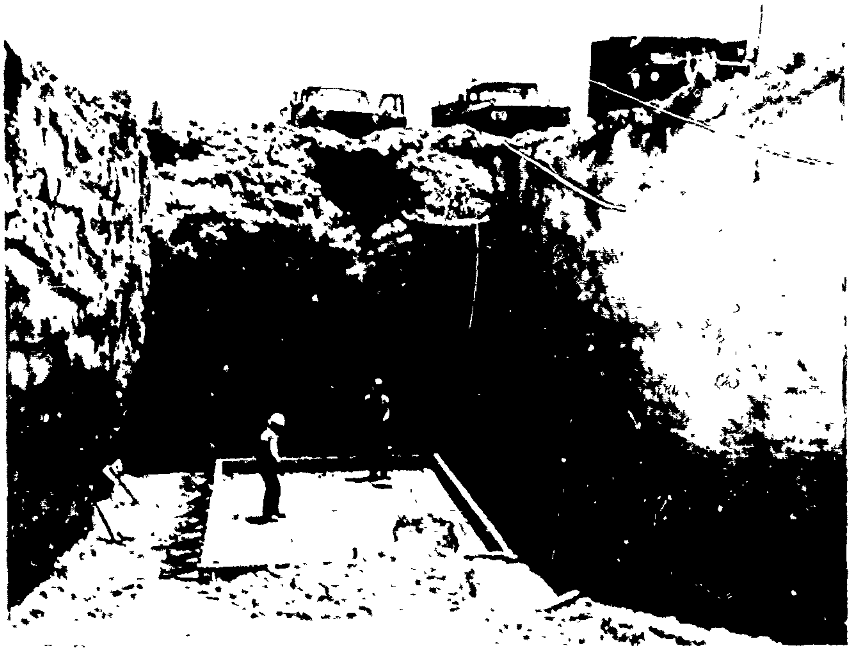


Figure 3-69. FRG/WES Overview of German Structures During Construction (Top Photo), and After Completion (Bottom Photo), DICE THROW



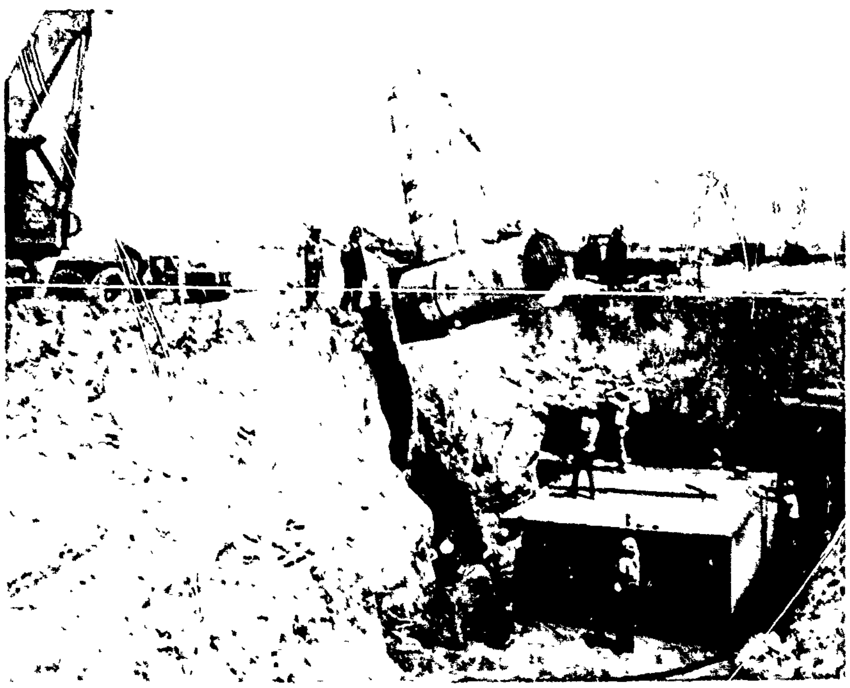


Figure 3-70. FRG/WES Rectangular Shear-Wall Design Structure Below Ground, DICE THROW

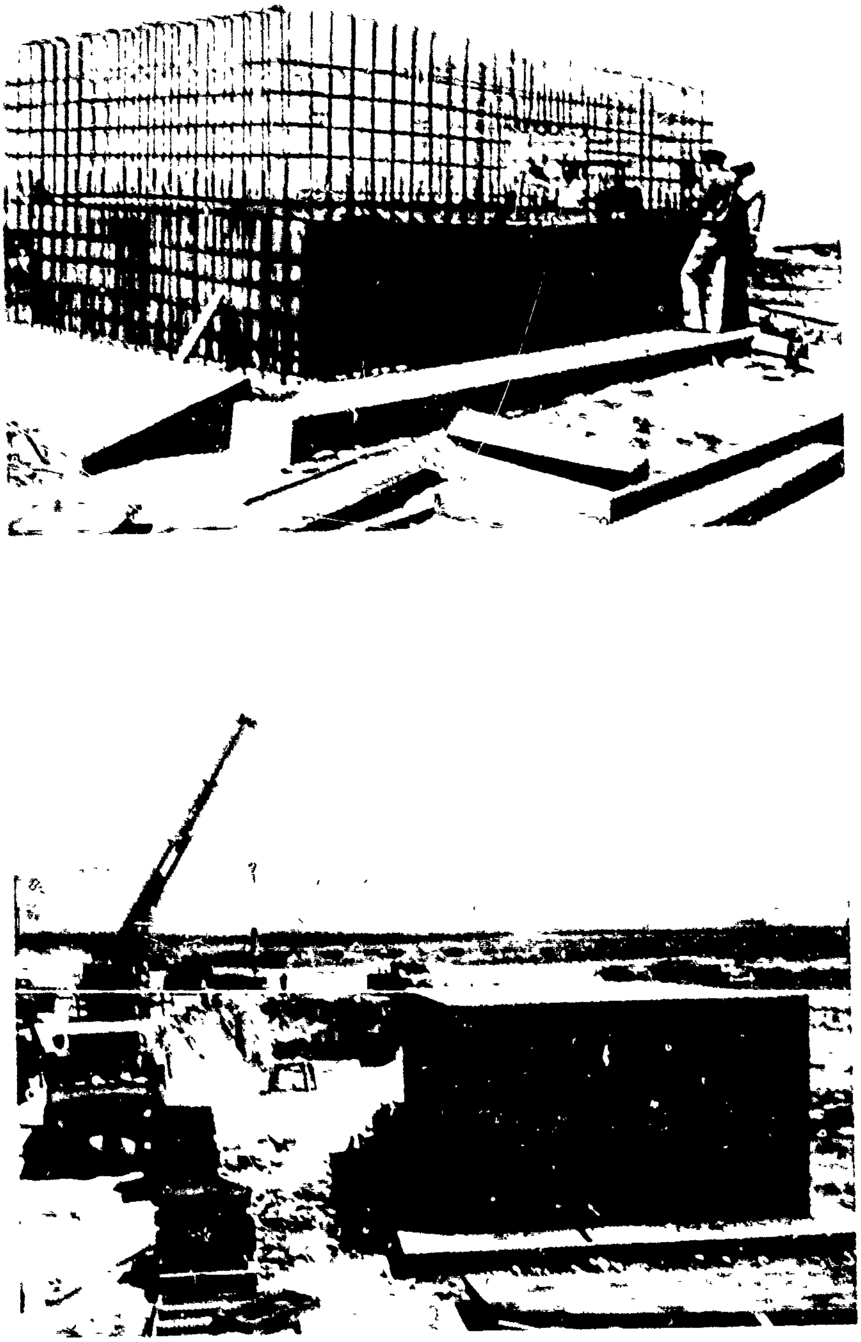


Figure 3-71. FRG/WES Rectangular Shear-Wall Design Structure, Above-Ground Location, DICE THROW

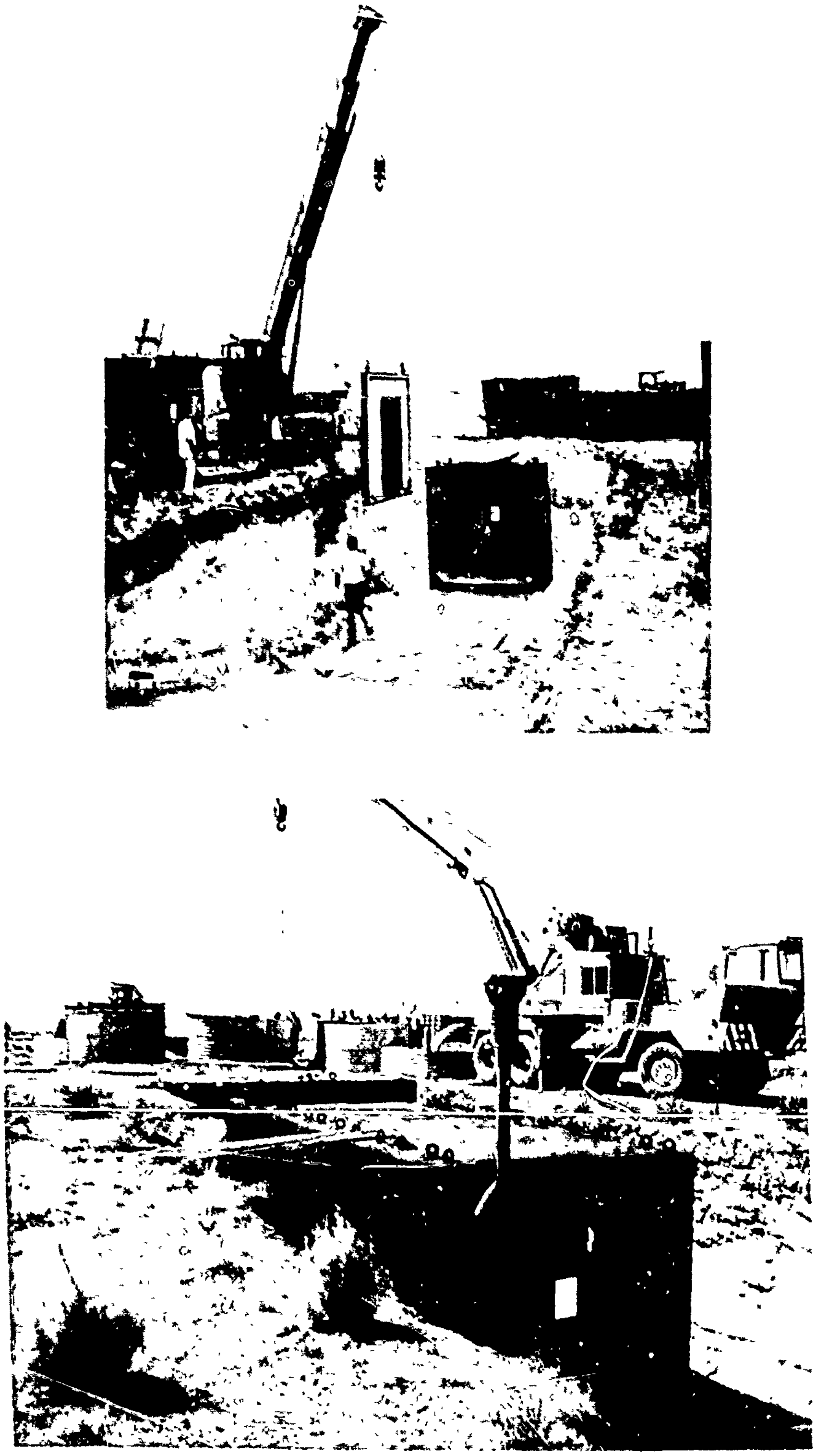


Figure 3-72. FRG/WES Full-Scale Prefabricated Modular Concrete Personnel Shelters, DICE THROW

personnel shelters (refer to Figure 3-73), and two blast doors (refer to Figure 3-74). During the main event, 175 channels of instrumentation were recorded. Data channels consisted of acceleration, velocity, strain, airblast pressure, and soil stress. Refer to Figure 3-75 for details pertaining to experiment layout.

After the main event, some testing using spherical charges of TNT are expected to be conducted on the undamaged FRG rectangular shear-wall structures to determine damage from simulated conventional weapons and to accumulate additional information on the internal shock environment caused by these weapons.

13. General Motors (GM)/Detroit Diesel Allison (DDA)/ARMCOM

TITLE: Ballistic Skirt/Hinge Subtest, Unity Vision Periscope/Universal Driver's Viewer, and Engine Compartment Fuel-Cell Subtest

PROJECT OFFICERS: Mr. Schnell and Mr. Herman

OBJECTIVES: (1) Determine if the hinges and bolts used to secure the skirts to the vehicle will withstand the blast environment and evaluate the deformation to the skirts; (2) determine if the integrity of the Commander's station unity-vision-periscope mounting hardware is maintained in the blast; and (3) determine the damage on a fuel tank due to differential pressure and flexure and evaluate any effects on the tanks mounting hardware.

EXPERIMENT DESCRIPTION: The ballistic skirts were secured by means of representative vehicle hinges to a holding fixture which is in turn secured by concrete to the ground (refer to Figure 3-76, top photo). The fixture was positioned side-on to the blast. High-speed movies were taken of the skirts during the course of the testing.

The unity-vision periscope and the Universal Driver's Viewer were mounted in a common test fixture (see Figure 3-76,

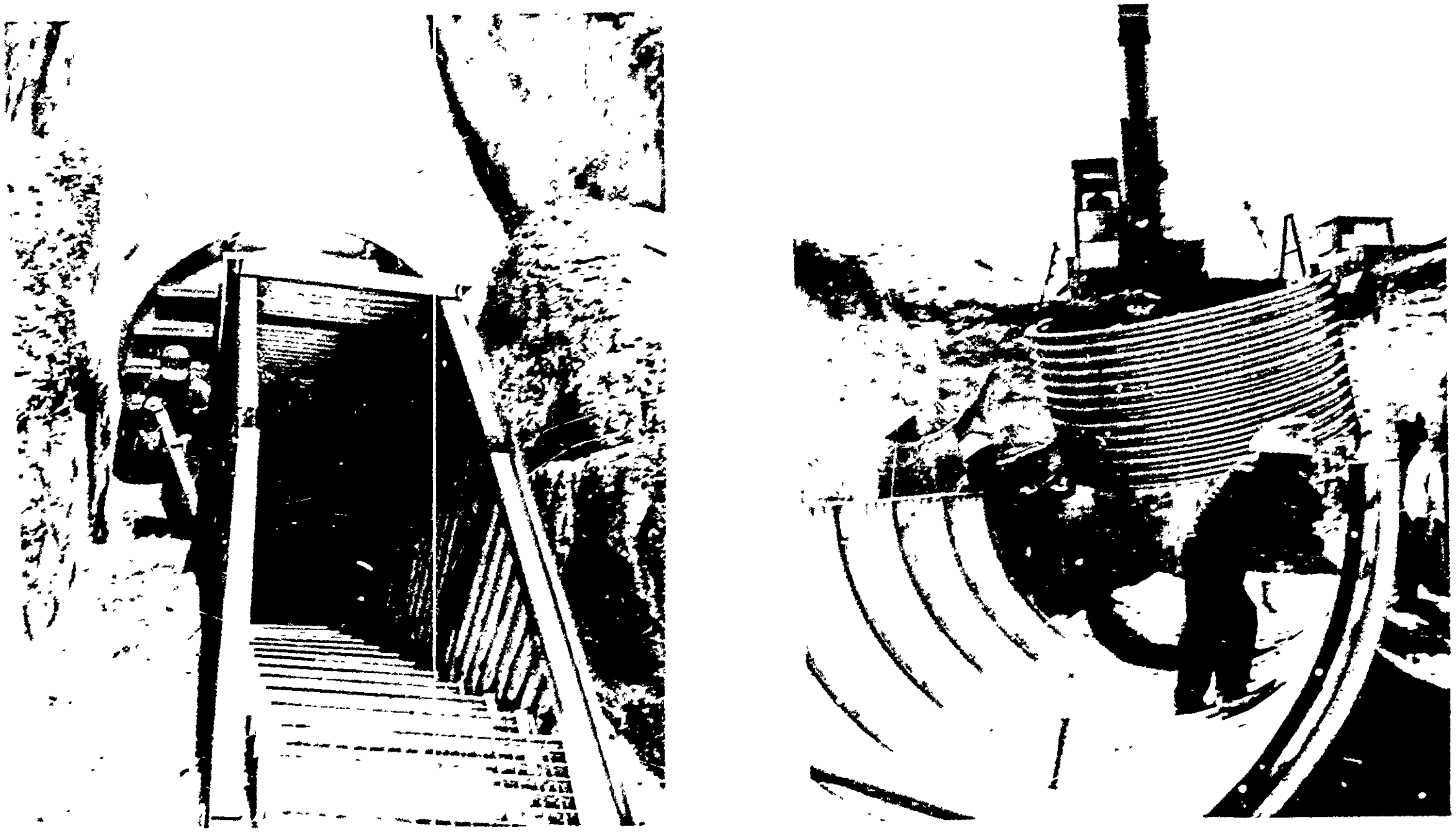


Figure 3-73. FRG/WES Full-Scale Prefabricated Corrugated-Metal Personnel Shelters, DICE THROW

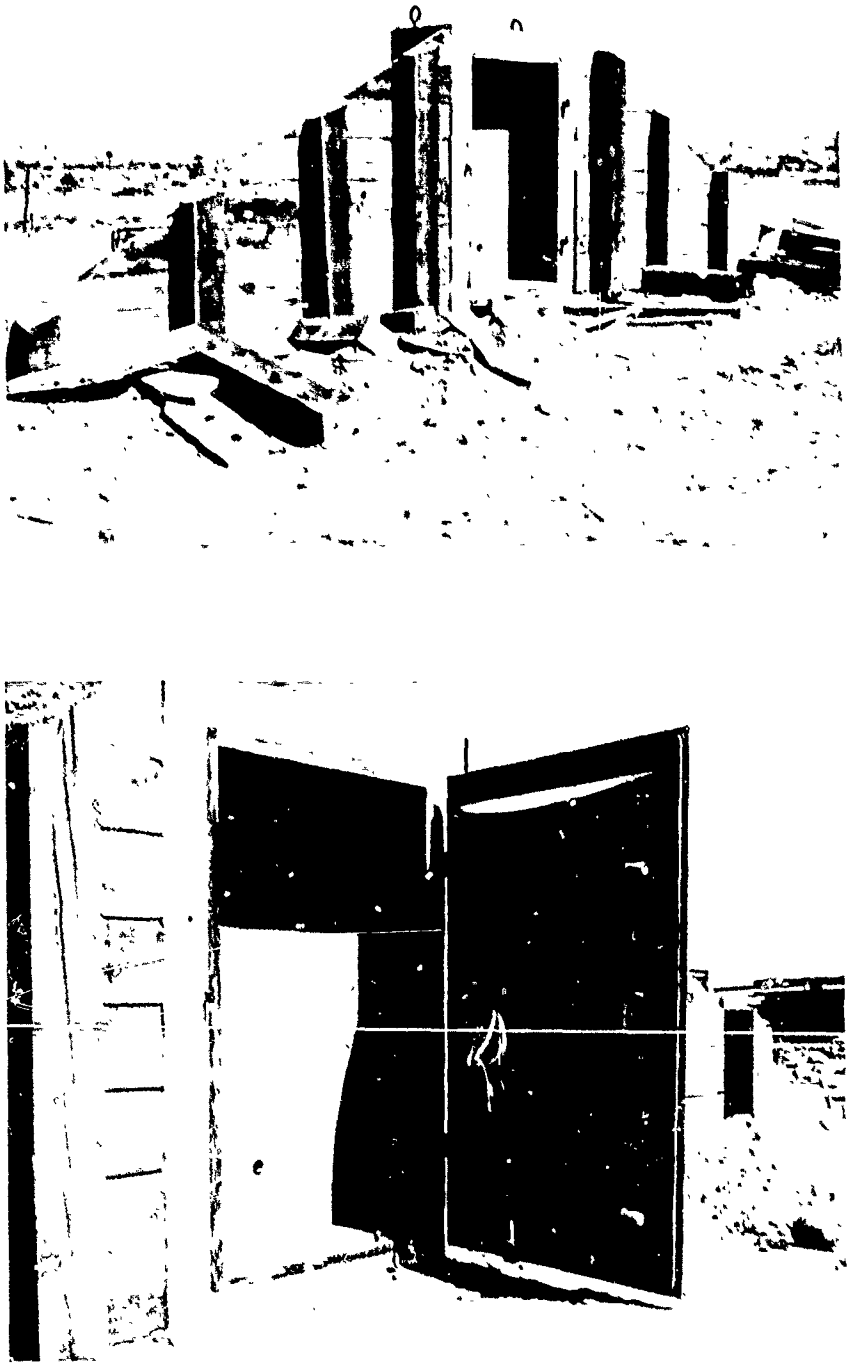


Figure 3-74. FRG/WES Blast-Door Configuration, DICE THROW

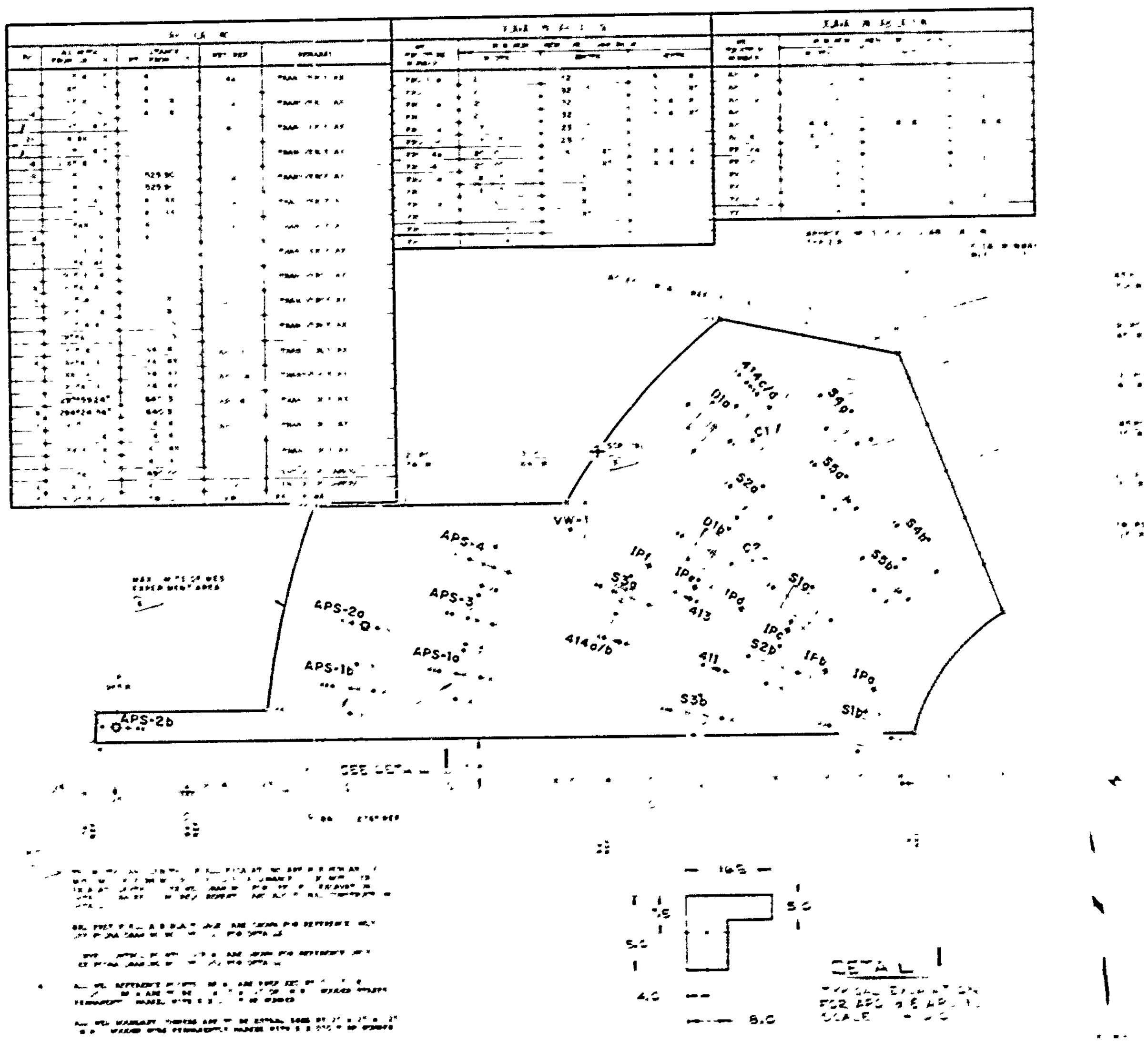


Figure 3-75. FRG/WES Experiment Layout on DICE THROW

Figure 3-76. GM/DDA Ballistic Skirt (Top Photo), Unity-Vision Periscope and Universal Driver's Viewer (Bottom Photo), DICE THROW

bottom photo) and oriented such that the optical surfaces of the devices faced the blast.

The fuel cell was mounted on a holding fixture which simulates the mounting interface provided with the hull. This holding fixture was secured in a reinforced concrete pit which was covered by a simulated engine compartment grill (see Figure 3-77). A pressure transducer, supplied by WSMR, was mounted to the fuel-cell-holding fixture to record the blast pressure.

14. Lawrence Livermore Laboratory (LLL), DNA Project #969

TITLE: Explosive Performance Diagnostics

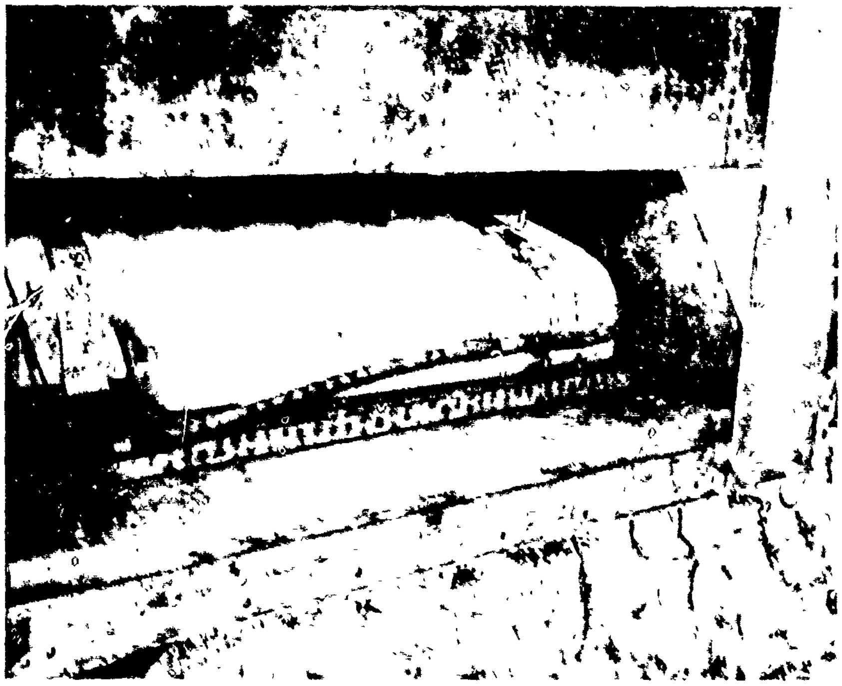
PROJECT OFFICER: Mr. B. Hayes (415) 447-1100

OBJECTIVES: Provide performance diagnostics by monitoring the sequence of events beginning with the firing of the booster detonators and ending with the ANFO detonation wave along the main radials within the charge.

EXPERIMENT DESCRIPTION: (Refer to Figure 3-78) Five measurements were recorded: detnogram, BIS simultaneity, transit times, pressure and detonation velocity.

(1) Detnogram: A detnogram record was to be made to depict the characteristic performance-time of events beginning with the start of current into the detonator bridgewire and ending with the output impulse. The purpose of this measurement is to sample a representative detonator for comparison with prior certification tests. In addition, the detnogram would provide an absolute zero time for the sequence of events which followed. It will be compared with the fiducial signal and serve as the zero time for the simultaneity BIS measurement.

(2) BIS Simultaneity: Barium Titanate (BaTi) polarized signal pins attached to the outside of the Octol explosive served to measure the arrival time of the booster waves at the driver-acceptor interface. The expectation was that there would be seven simultaneous arrival signals. To



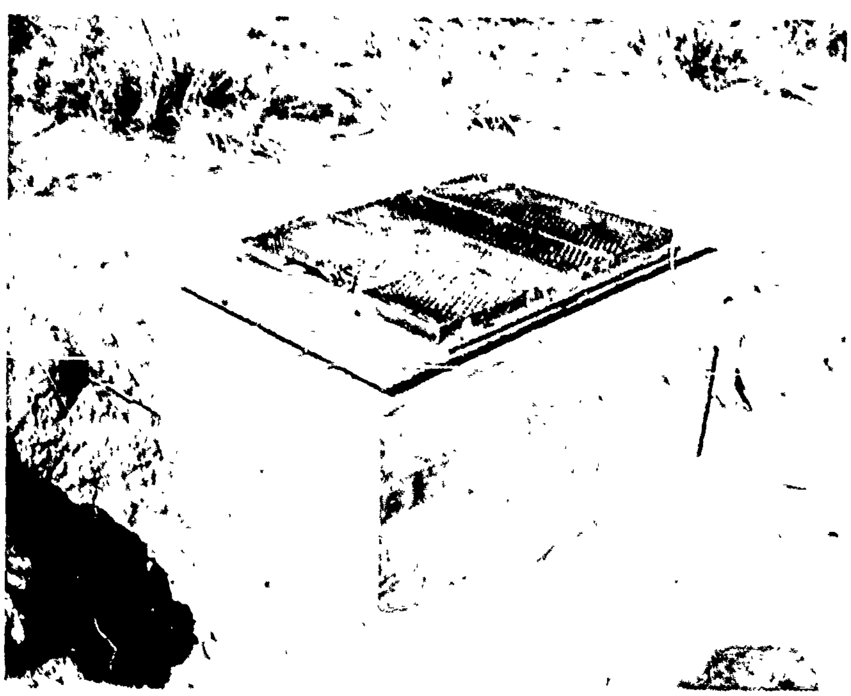


Figure 3-77. GM/DDA Fuel Tank (Top Photo), Holding Fixture (Bottom Photo), DICE THROW

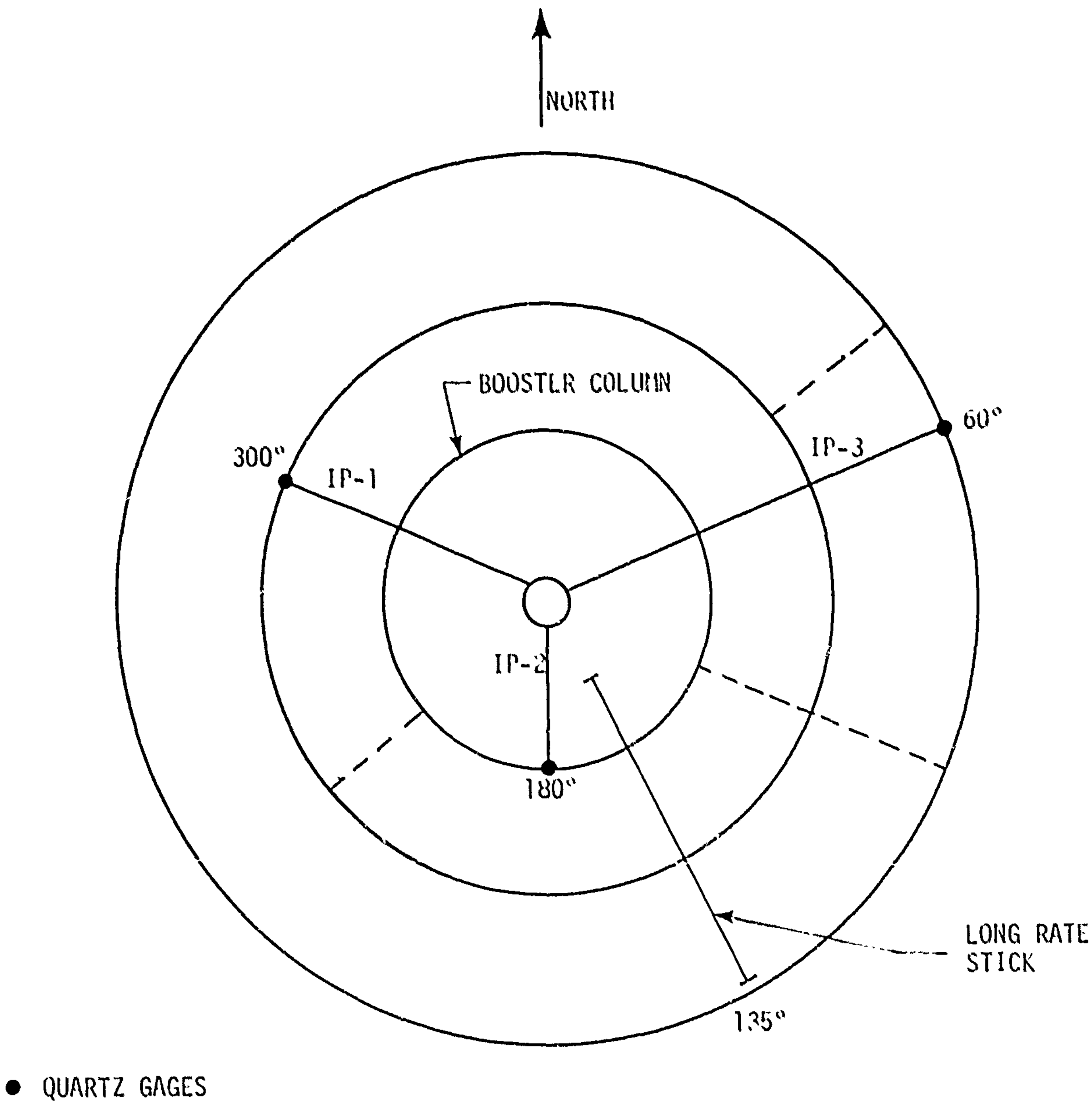


Figure 3-78. LLL Experiment Location Within the ANFO Charge, DICE THROW

accommodate these signals, the four odd-numbered booster column signals were mixed and delay-looped for display on a raster pin machine. Similarly, the three even-numbered booster column signals were displayed on a separate pin machine. In addition, the even-numbered signals started the time-interval meters for transit-time measurements along the main radials.

(3) Transit Times: BaTi trigger pins located along the instrument park (IP) radials served to trigger quartz gage pressure record oscilloscopes and stop the time-interval meters. Transit-time measurements were taken at 3, 6 and 9 ft (1, 2 and 3 m) from the booster column along IP-1, IP-2 and IP-3, respectively. The vertical positions were at booster levels 2, 4 and 6, respectively, numbering from the ground up. Exact measurements of the implanted pins were noted during stacking to obtain average detonation velocities over the radial distances. This information is also used to correlate the pressure measurements.

(4) Quartz Gages: Three pressure transducer quartz gages were embedded in the ANFO stack along radials IP-1, IP-2 and IP-3, at the termination of the transit-time pins. These gages generate a signal current which is proportional to the stress in the quartz. Standard impedance matching formulae relate the transducer signals to the detonation pressure. Characterization of the ANFO stack is accomplished by the interrelationship of the stack density, detonation velocity and peak pressure.

(5) Long Rate Stick: The constancy of the detonation velocity relates to the steady-state behavior of the explosive. The large cellular construction demanded by the stacking introduces voids, gaps and shock interactions. The purpose of the long rate stick, sampling the shock front approximately every 100-μs, is to observe excursions about some average

velocity. The rate stick was embedded in the stack opposite the third booster along the IP-1 radial. It had eight stations, and the record was recorded on an extended-time raster scope.

15. Lovelace Foundation (LF)

TITLE: Blast Displacement Effects in Field Fortifications, DNA Project #408

PROJECT OFFICER: Mr. R. Clark (505) 264-6088

OBJECTIVES: Measure the motion of dummies exposed to the airblast-induced flow into open fighting bunkers by monitoring with high speed photography, self-recording accelerometers mounted in the chest cavity of each dummy and measuring stagnation and static pressure properties of the entering blast flow.

EXPERIMENT DESCRIPTION: Three identical 3x6-ft (1x2-m) fighting bunkers were used in this project (refer to Figure 3-79). Each bunker had a firing port on the front and an access ramp on the back. The bunkers were constructed of 1/8-in. (0.32-cm) steel plate welded to a frame of 2x2-in. (5x5-cm) angle iron. The bunkers were fabricated by the Lovelace Laboratory. An underground command bunker was also fielded at the 20-psi (140-kPa) level in the ARMCOM area (refer to Figure 3-80).

One face-on bunker was located at 680 ft (207 m) (25 psi (175 kPa)) and two bunkers (one face-on and one side-on) were located at 820 ft (250 m) [15 psi (105 kPa)] from ground zero.

Six anthropomorphic dummies, simulating men of average size and weight, were constructed at the Lovelace Laboratory. Each has most of the primary moveable joints and each has an accessible chest cavity for installing instrumentation. The dummies were clothed in G.I. fatigue uniforms with boots and motorcycle helmets. The helmet straps were fastened tightly

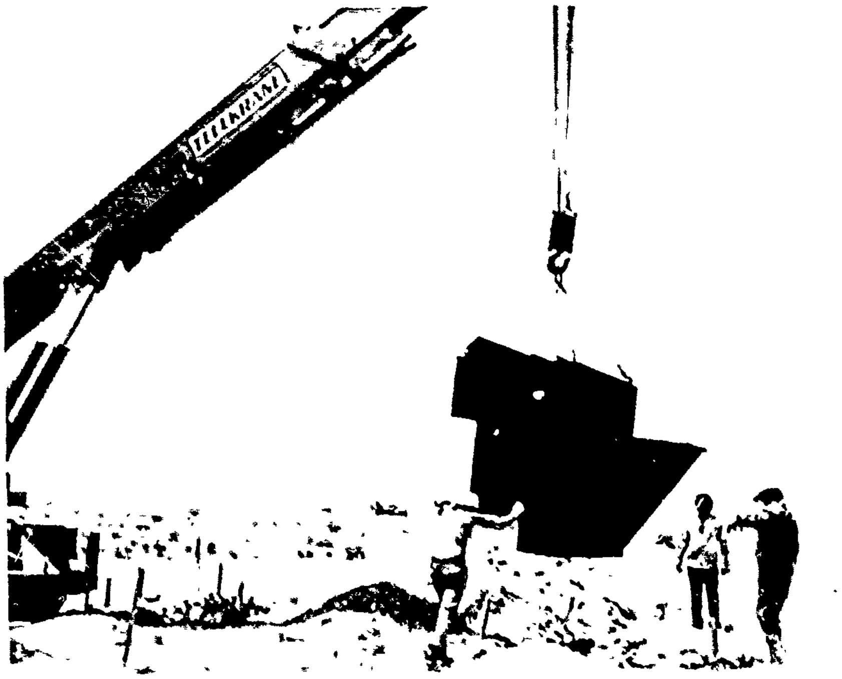
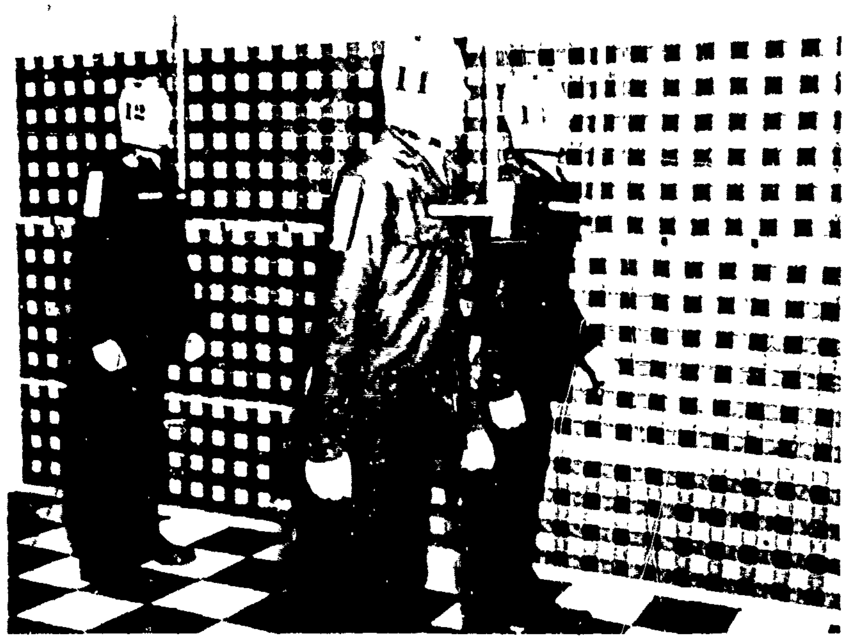


Figure 3-79. LF Fighting Bunkers, DICE THROW



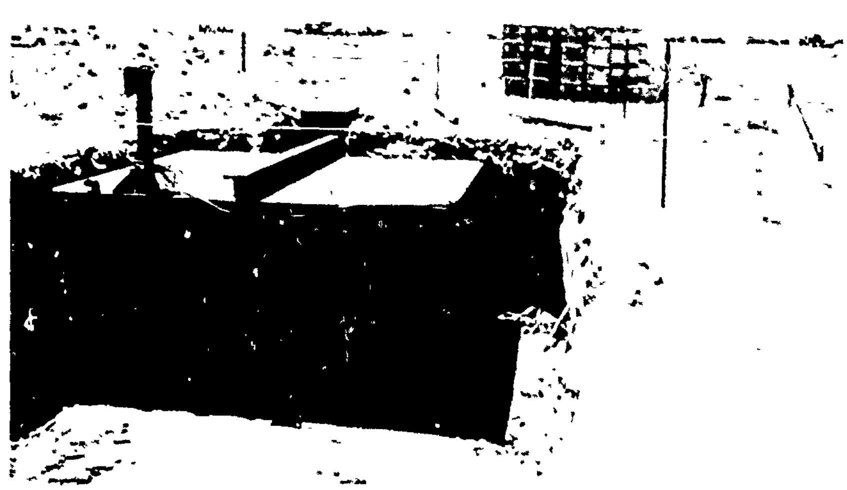


Figure 3-80. LF Underground Command Bunker with Anthropomorphic Dummies, DICE THROW

around the chins of the dummies. One standing and one kneeling dummy faced the firing port in each bunker. The heads of the dummies were in line with the firing port.

Four omni-directional, mechanical accelerometers called Impact-O-Graphs were mounted in the chest cavity of each dummy. Each Impact-O-Graph contains four steel spheres which are held in four small cups by two springs. When a specified peak acceleration is exceeded, either one or both pairs of spheres should be dislodged depending on the direction of the acceleration. The four Impact-O-Graphs in each dummy were rated to unload when the peak acceleration exceeded either 10, 40, 200 or 800 g's. Calibration experiments were performed by dropping the dummies flat on a concrete pad in either a back-, chest- or shoulder-on orientation.

There were three Redlake Locam cameras which were the responsibility of Denver Research Institute. One camera was mounted in an alcove in the right-hand wall (with respect to the dummies) of each bunker. The field-of-view was illuminated by four slow-burning Sylvania flash lamps. Timing signals were used to operate relays to power the lights and camera from a battery in each bunker. Pre- and post-shot still photographs were taken of the dummies.

Instrumentation included seven pressure gages which were supplied, installed and operated by Ballistic Research Laboratory (BRL). A free-field, side-on pressure gage was located approximately 40 ft (12.2 m) to the side of the bunkers at the 680- and 820-ft (207- and 250-m) ground ranges. One side-on gage was located on the side wall opposite the camera in each bunker. The stagnation probe was located in each face-on bunker. These probes were centered vertically with respect to the firing port so as to receive the maximum stagnation pressure of the entering blast. Refer to Figure 3-81 for a layout of this experiment.

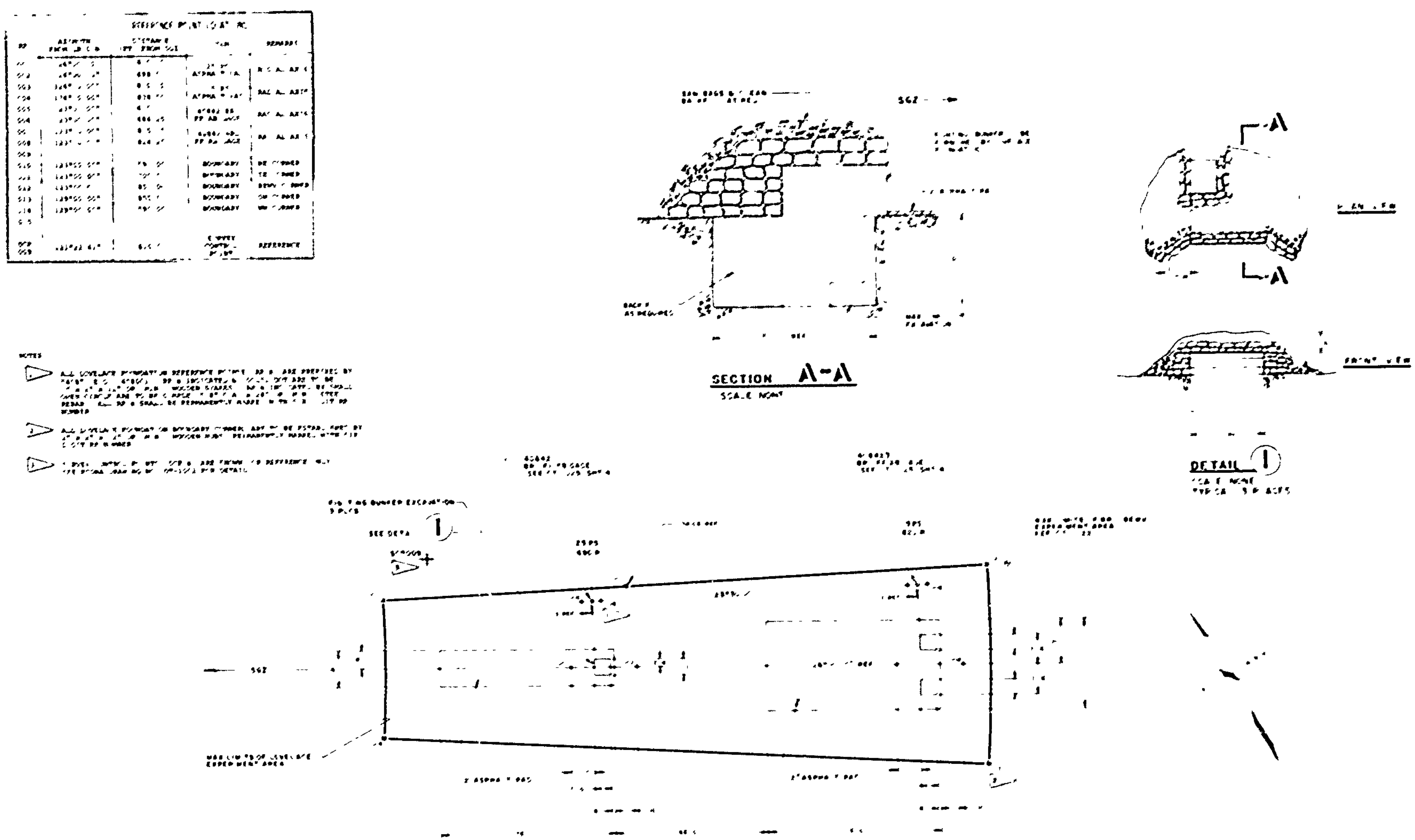


Figure 3-81. Lovelace Foundation Fighting Bunker Layout on DICE THROW

16. Naval Weapons Evaluation Facilities (NWEF)

TITLE: Aircraft Overpressure Vulnerability, DNA Project #118

PROJECT OFFICER: Mr. V. Stanley (505) 264-9951

OBJECTIVE: Verify the computer code predictions for overpressure damage to aircraft. These codes are described in the Handbook for Analysis of Nuclear Weapon Effects on Aircraft, DNA-2048H.

EXPERIMENT DESCRIPTION: Three Navy A-4C aircraft were placed side-on to the blast wave to measure the structural response of skin panels, stiffeners and frames. Two aircraft were placed at 1230 ft, 6 psi (375 m, 42 kPa) from GZ and the third aircraft was placed at a range of 1025 ft, 9 psi (312 m, 63 kPa) (refer to Figure 3-82).

Medium-speed, motion picture cameras (400 frames/second) were directed at each aircraft to record the rigid-body motion. One aircraft at the 6-psi (42-kPa) location was unrestrained to simulate a flight deck launch condition. The other two aircraft were tied down securely. These tie-downs included calibrated load cells to measure the overturning forces.

One aircraft at 6 psi (42 kPa) was instrumented to allow recording of structural strain, panel displacement and local pressure. There were 58 channels of strain data, 10 channels of pressure transducers and three channels of displacement data. These channels were recorded in a DNA trailer at trailer park #1. The off-loading on one test item is shown in Figure 3-83 along with an overview of the test area.

17. Netherlands/Ballistic Research Laboratory (BRL)

TITLE: Blast Effects on a Foreign Tactical Weapon System, DNA Project #135

PROJECT OFFICER: Mr. R. Raley (301) 278-4912

OBJECTIVES: (1) Determine blast response on a Netherlands Personnel Carrier using cameras, pressure gages, accelerometers

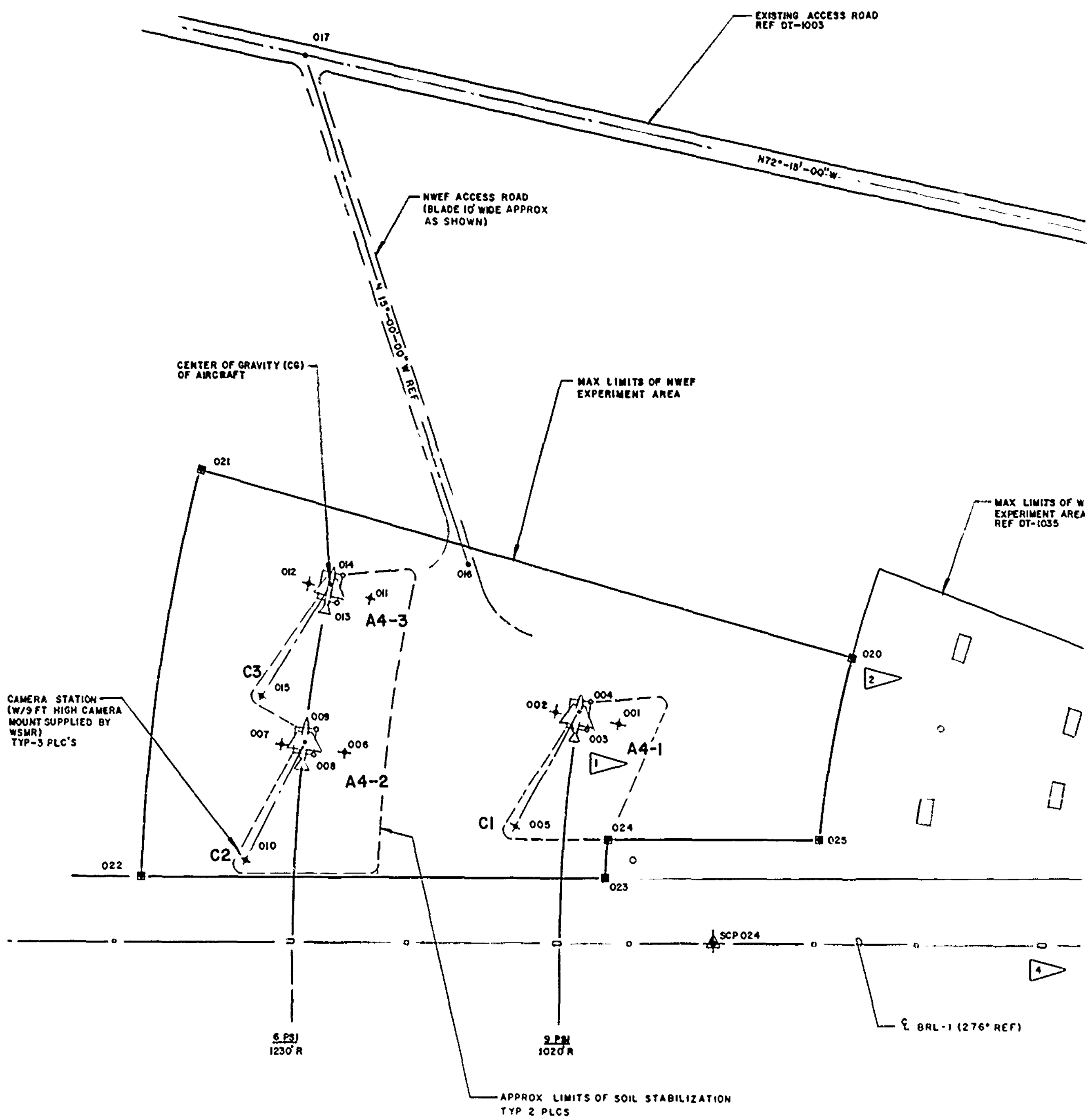
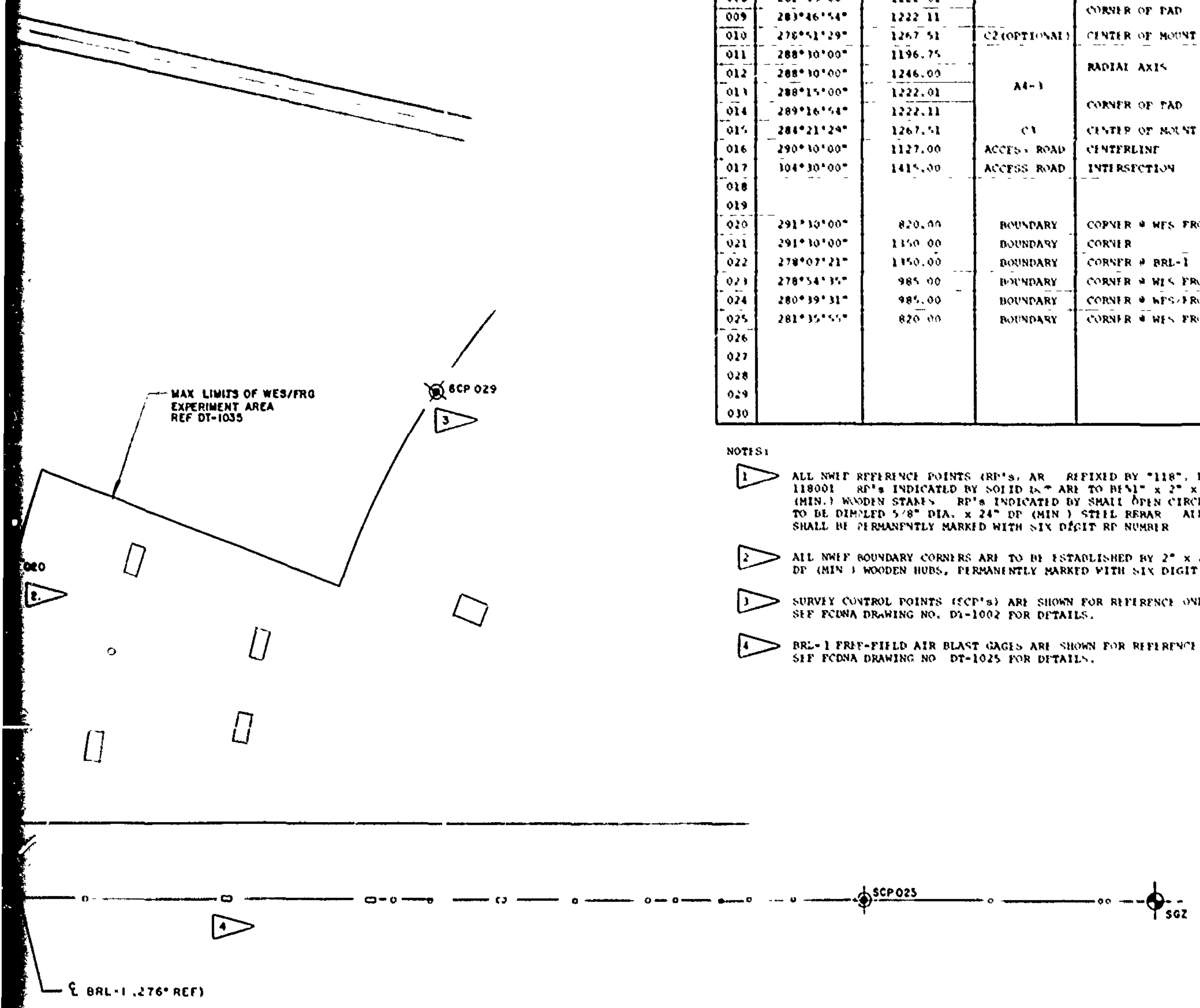


Figure 3-82. NWEF Experiment Layout, DICE THROW



REFERENCE POINT LOCATIONS

RP	AZIMUTH (FROM GRID N)	DISTANCE (FT. FROM SGZ)	ITEM	REMARKS
001	285°45'00"	986.75	A4-1	RADIAL AXIS
002	285°45'00"	1036.00		
003	285°26'54"	1012.01		CORNER OF PAD
004	286°41'37"	1012.14		
005	280°47'12"	1058.17	C1	CENTER OF MOUNT
006	283°00'00"	1196.75	A4-2	RADIAL AXIS
007	283°00'00"	1246.00		
008	282°45'00"	1222.01		CORNER OF PAD
009	283°46'54"	1222.11		
010	278°51'29"	1267.51	C2 (OPTIONAL)	CENTER OF MOUNT
011	288°30'00"	1196.75	A4-3	RADIAL AXIS
012	288°30'00"	1246.00		
013	288°15'00"	1222.01		CORNER OF PAD
014	289°16'54"	1222.11		
015	284°21'29"	1267.51	C3	CENTER OF MOUNT
016	290°30'00"	1127.00	ACCESS ROAD	CENTERLINE
017	304°30'00"	1415.00	ACCESS ROAD	INTERSECTION
018				
019				
020	291°30'00"	820.00	BOUNDARY	CORNER @ WES FRG
021	291°30'00"	1150.00	BOUNDARY	CORNER
022	278°07'21"	1150.00	BOUNDARY	CORNER @ BRL-1
023	278°54'35"	985.00	BOUNDARY	CORNER @ WES FRG
024	280°39'31"	985.00	BOUNDARY	CORNER @ WES/FRG
025	281°35'55"	820.00	BOUNDARY	CORNER @ WES FRG
026				
027				
028				
029				
030				

NOTES:

1. ALL NWEF REFERENCE POINTS (RP's) ARE PREFIXED BY "118", E.G., 118001. RP's INDICATED BY SOLID ▲ ARE TO BE 1" x 2" x 12" DP (MIN.) WOODEN STAKES. RP's INDICATED BY SMALL OPEN CIRCLE ARE TO BE DIMPLED 5/8" DIA. x 24" DP (MIN.) STEEL REBAR. ALL RP's SHALL BE PERMANENTLY MARKED WITH SIX DIGIT RP NUMBER.

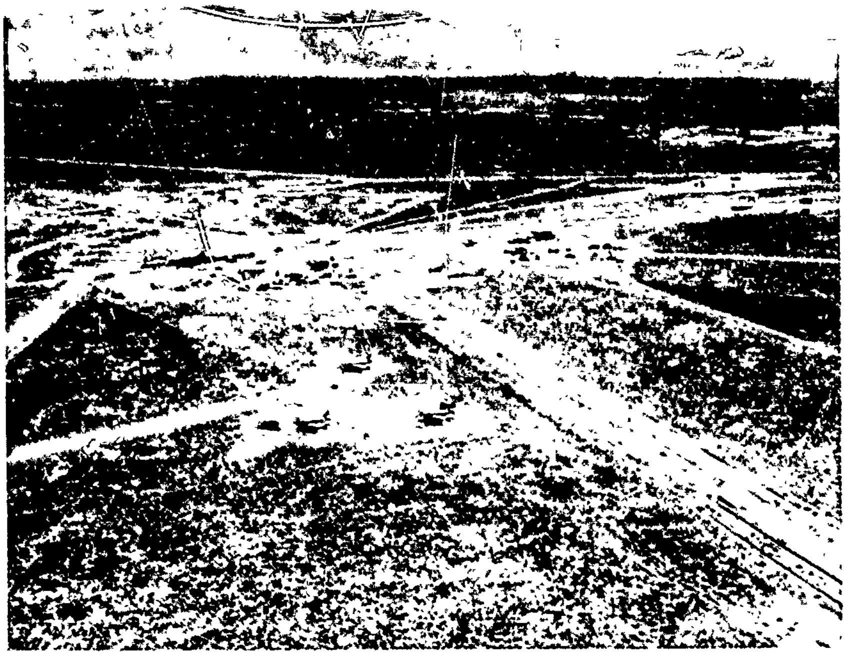
2. ALL NWEF BOUNDARY CORNERS ARE TO BE ESTABLISHED BY 2" x 2" x 12" DP (MIN.) WOODEN HUBS, PERMANENTLY MARKED WITH SIX DIGIT RP NUMBER.

3. SURVEY CONTROL POINTS (SCP's) ARE SHOWN FOR REFERENCE ONLY. SEE FCDNA DRAWING NO. DT-1002 FOR DETAILS.

4. BRL-1 FREE-FIELD AIR BLAST GAGES ARE SHOWN FOR REFERENCE ONLY. SEE FCDNA DRAWING NO. DT-1025 FOR DETAILS.

ROW

2



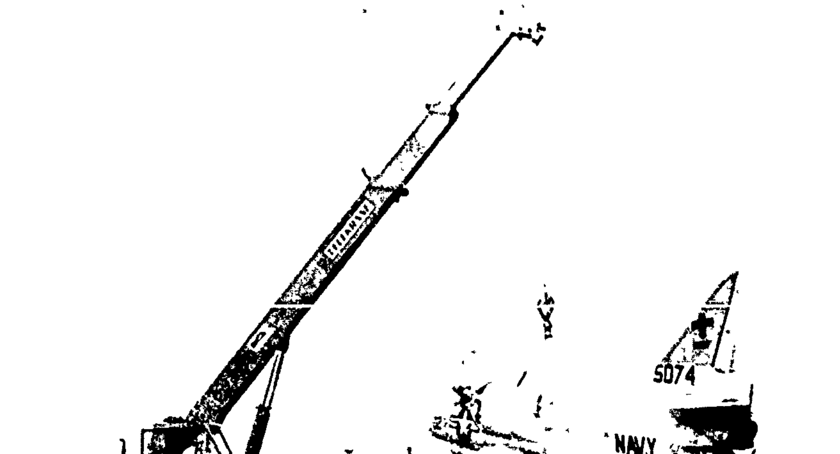


Figure 3-83. NWEF Experiment Overview (Top Photo) and Off-Loading Procedure (Bottom Photo), DICE THROW

and instrumented anthropomorphic dummies. (2) Record damage to the system and correlate data with data obtained from blast effects experiments on similar U. S. Army weapons system.

EXPERIMENT DESCRIPTION: An Armored Infantry Fighting Vehicle (AIFV) was to be exposed at the 15-psi (105-kPa) overpressure level and oriented 45 degrees to the incident blast wave. The vehicle was combat loaded with commander's hatch, firing ports and driver's hatch open. MOD/GON supplied the dummy which was placed in the commander's hatch. BRL/LF supplied the two dummies which were placed in the crew compartment. Refer to the photographs in Figure 3-84.

Instrumentation consisted of two high-speed cameras for interior and exterior views; three dummies instrumented with peak reading accelerometers; three interior overpressure measurements; and three accelerometers. This test item was located in the ARMCOM area near camera station C22. Refer to that experiment layout figure.

18. Norway/University of New Mexico Civil Engineering Research Facility (CERF)

TITLE: Ammunition Facility Blast Door, DNA Project #61

PROJECT OFFICERS: Dr. G. Lane/CERF (505) 264-4644 and Dr. A. Skeljtorp/NDCS

OBJECTIVE: Determine structural response of an ammunition storage facility concrete blast door.

EXPERIMENT DESCRIPTION: The Norwegian Defense Construction Service (NDCS) fielded an ammunitions storage facility blast door at an overpressure of 210 psi (1470 kPa). The Civil Engineering Research Facility (CERF) was responsible for the construction, monitoring, instrumentation, and reporting of the project (refer to Figure 3-85 for the layout of this experiment).

Participation in the DICE THROW event served to qualify the proposed blast-door structure as a Norwegian, and possibly NATO, standard for use on ammunition facilities, and for use in civil defense protective installations.

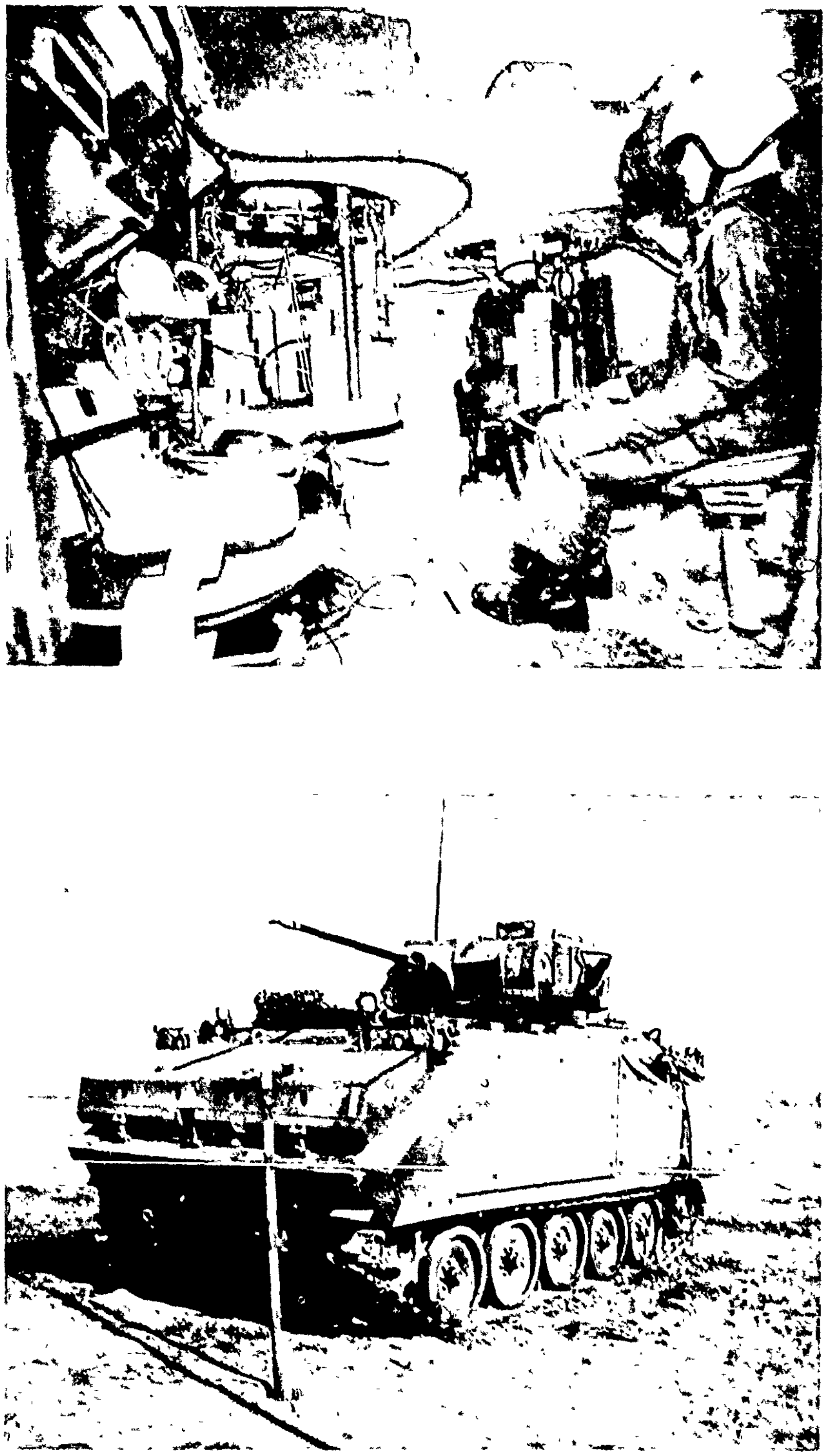
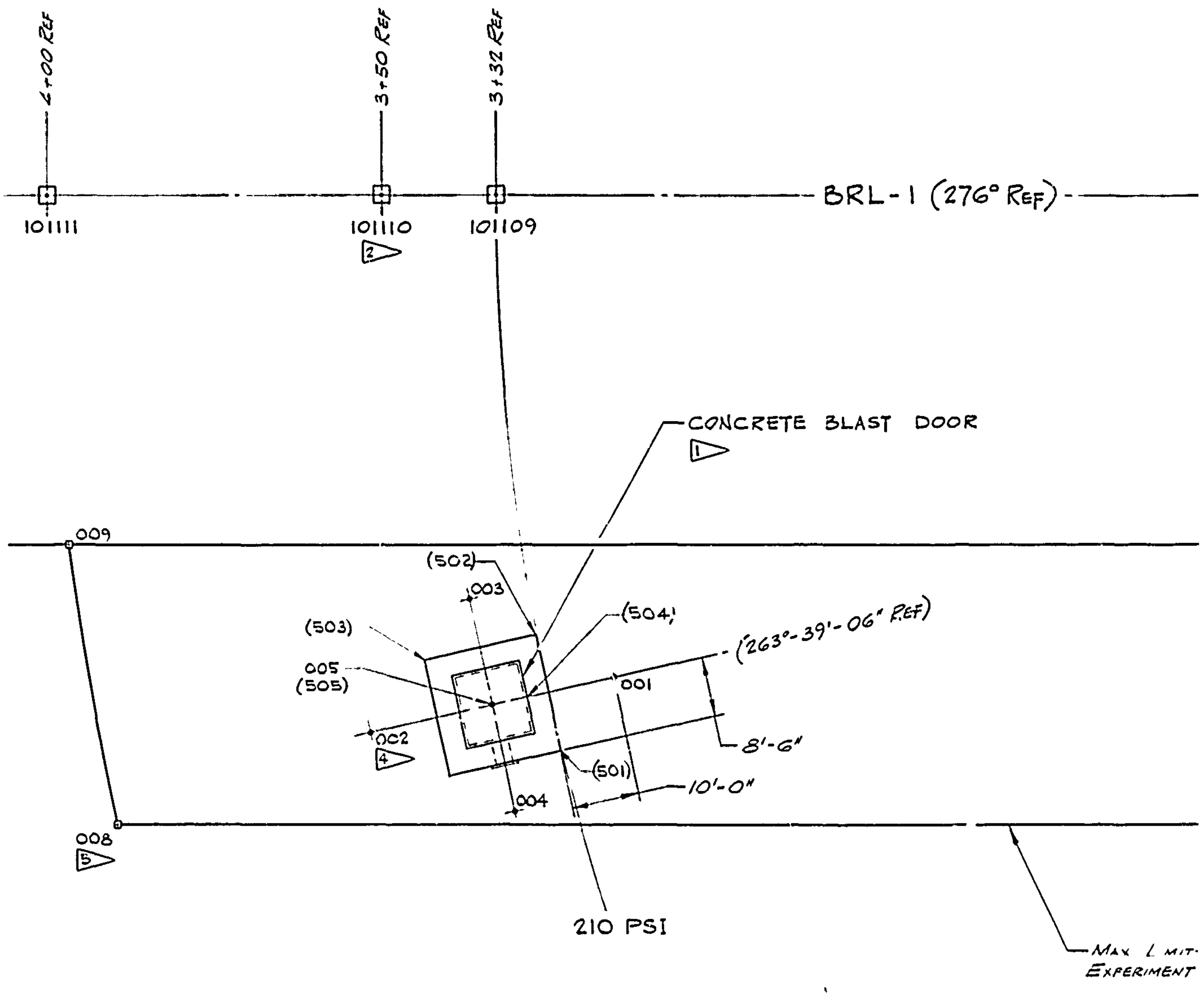


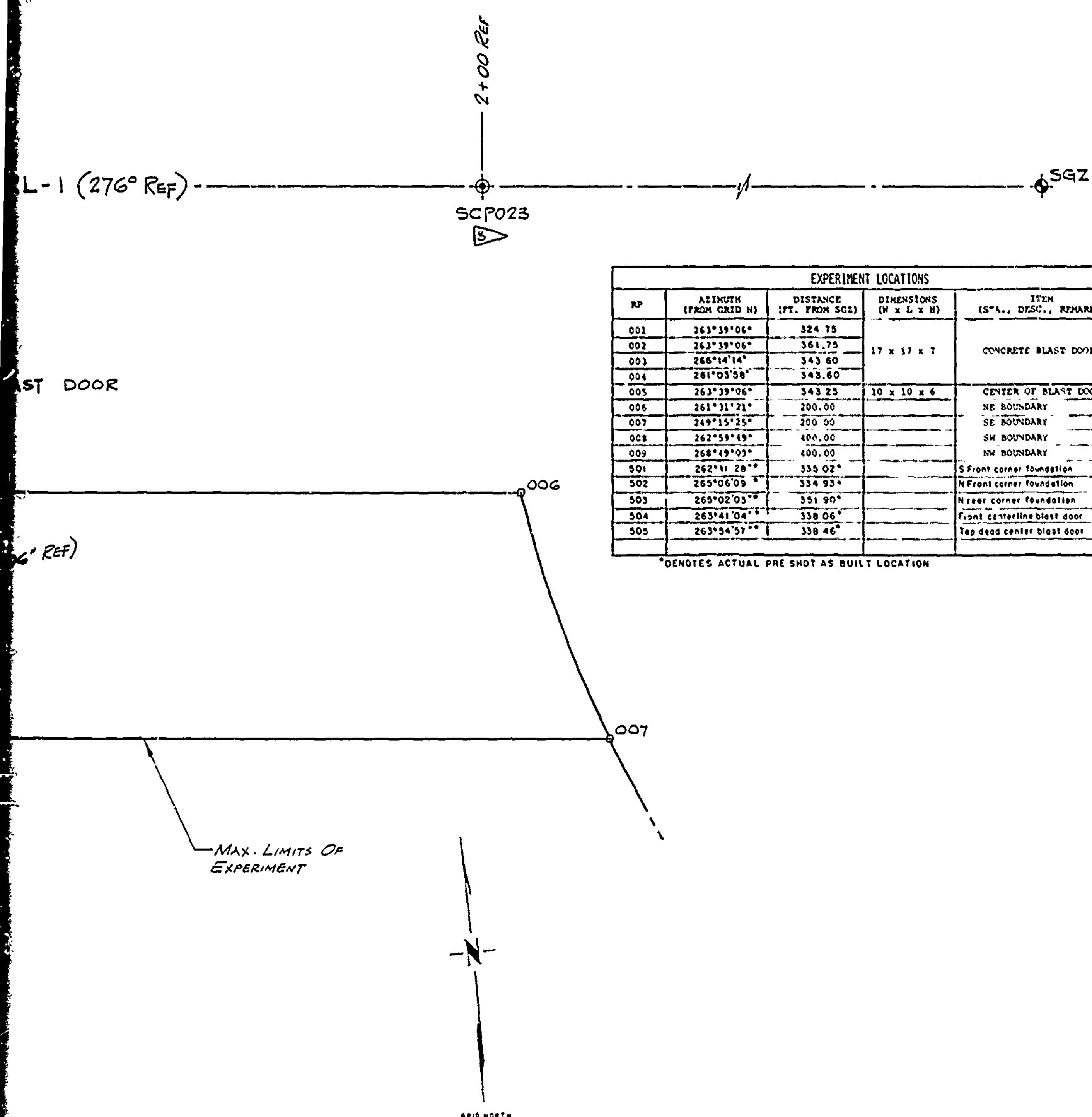
Figure 3-84. Netherlands/BRL Personnel Carrier Interior and Exterior Views, DICE THROW



NOTES:

1. SEE CERF DRAWING NO. 72109-012 FOR CONSTRUCTION DETAILS.
2. BRL FREE-FIELD AIR BLAST GAGES ARE SHOWN FOR REFERENCE ONLY. SEE FCDNA DRAWING NO. DT-1025 FOR CONSTRUCTION DETAILS.
3. SURVEY CONTROL POINTS (SCP's) ARE SHOWN FOR REFERENCE ONLY. SEE FCDNA DRAWING NO. D.-1002 FOR DETAILS
4. ALL CERF/NORWAY REFERENCE POINTS ARE PREFIXED BY "160"; E.G., 160002.
5. RP 160009 IS A MUTUAL REFERENCE POINT WITH 169005 AND RP 160008 IS MUTUAL WITH 169006.

Figure 3-85. Norway/CERF Experiment Layout, DICE THROW



EXPERIMENT LOCATIONS				
RP	AZIMUTH (FROM GRID N)	DISTANCE (FT. FROM SGZ)	DIMENSIONS (W x L x H)	ITEM (STA., DESC., REMARKS)
001	263°39'06"	324 75	17 x 17 x 7	CONCRETE BLAST DOOR
002	263°39'06"	361.75		
003	266°14'14"	343 60		
004	261°03'58"	343.60		
005	263°39'06"	343 25	10 x 10 x 6	CENTER OF BLAST DOOR
006	261°31'21"	200.00		NE BOUNDARY
007	249°15'25"	200 00		SE BOUNDARY
008	262°59'49"	400.00		SW BOUNDARY
009	268°49'03"	400.00		NW BOUNDARY
501	262°11 28"*	335 02*		S Front corner foundation
502	265°06'09 *	334 93*		N Front corner foundation
503	265°02'03"*	351 90*		N rear corner foundation
504	263°41'04"*	338 06*		Front centerline blast door
505	263°54'57"*	338 46*		Top dead center blast door

*DENOTES ACTUAL PRE SHOT AS BUILT LOCATION

THROW

2

The reinforced concrete blast door was approximately 10 ft (3 m) square and 1 ft (.03 m) thick and was mounted horizontally on a surface-flush reaction pit. Measurements made on the door consisted of strain on the reinforcing steel, both passive and active vertical displacements and accelerations on both the door and the reaction foundation. The photographs in Figure 3-86 show the blast door during the construction and gage installation phases.

19. Oak Ridge National Laboratory (ORNL)

TITLE: Blast Tests of Expedient Shelters, DNA Project #318

PROJECT OFFICER: Dr. C. Kearney (615) 483-1549

OBJECTIVE: Obtain field data useful in making more reliable estimates of the practical limitations of expedient shelters and their expedient life-support equipment.

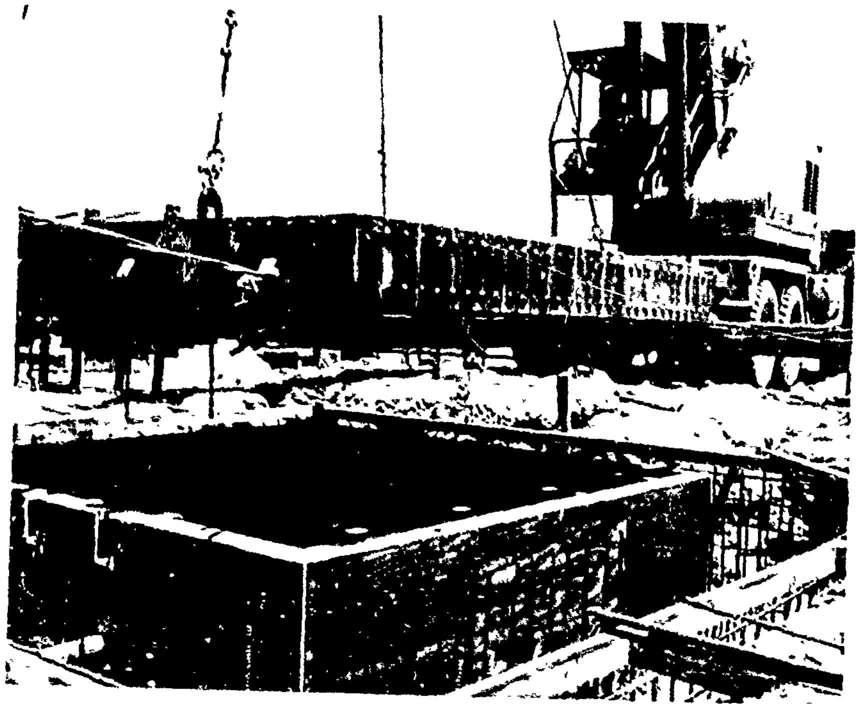
EXPERIMENT DESCRIPTION: Nine expedient shelters (most of which were built as paired duplicates for 18 total shelters) were positioned at predicted overpressure ranges that make their failure likely (refer to Figure 3-87). The shelters included four of American design, three of Russian design and two of Chinese design (refer to Table 3-13 and Figures 3-88, 3-89 and 3-90). The survivability of these shelters was determined by measurements of the peak overpressure and deflection by measurements and photographs of shelters components before and after the test and, for one of the shelters, by a high-speed motion camera.

20. Rodman Laboratory (ARMCOM)/White Sands Missile Range (WSMR)

TITLE: Blast Effects on U. S. Army Operationally-Oriented Weapons Systems, DNA Project #36

PROJECT OFFICERS: Mr. R. Nelson/Rodman Laboratory (309) 793-6797 and Mr. J. Gorman/WSMR (915) 678-1161

OBJECTIVES: (1) Determine blast response of high-priority U. S. Army operationally-oriented weapons systems using cameras, pressure gages, accelerometers and inst   ented anthropomorphic



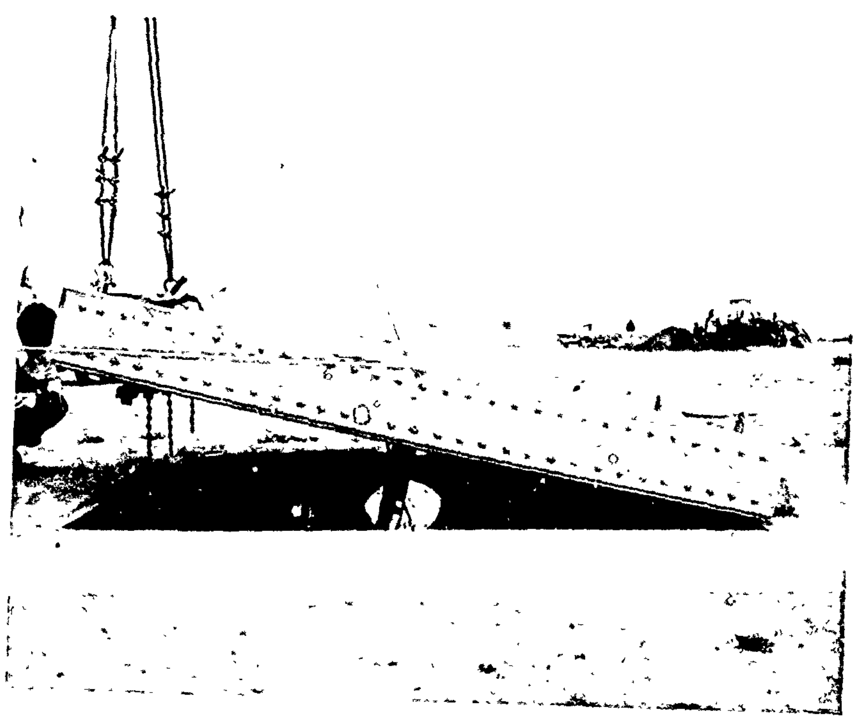


Figure 3-86. Norway/CERF Blast Door in the Construction and Gage Installation Phase.

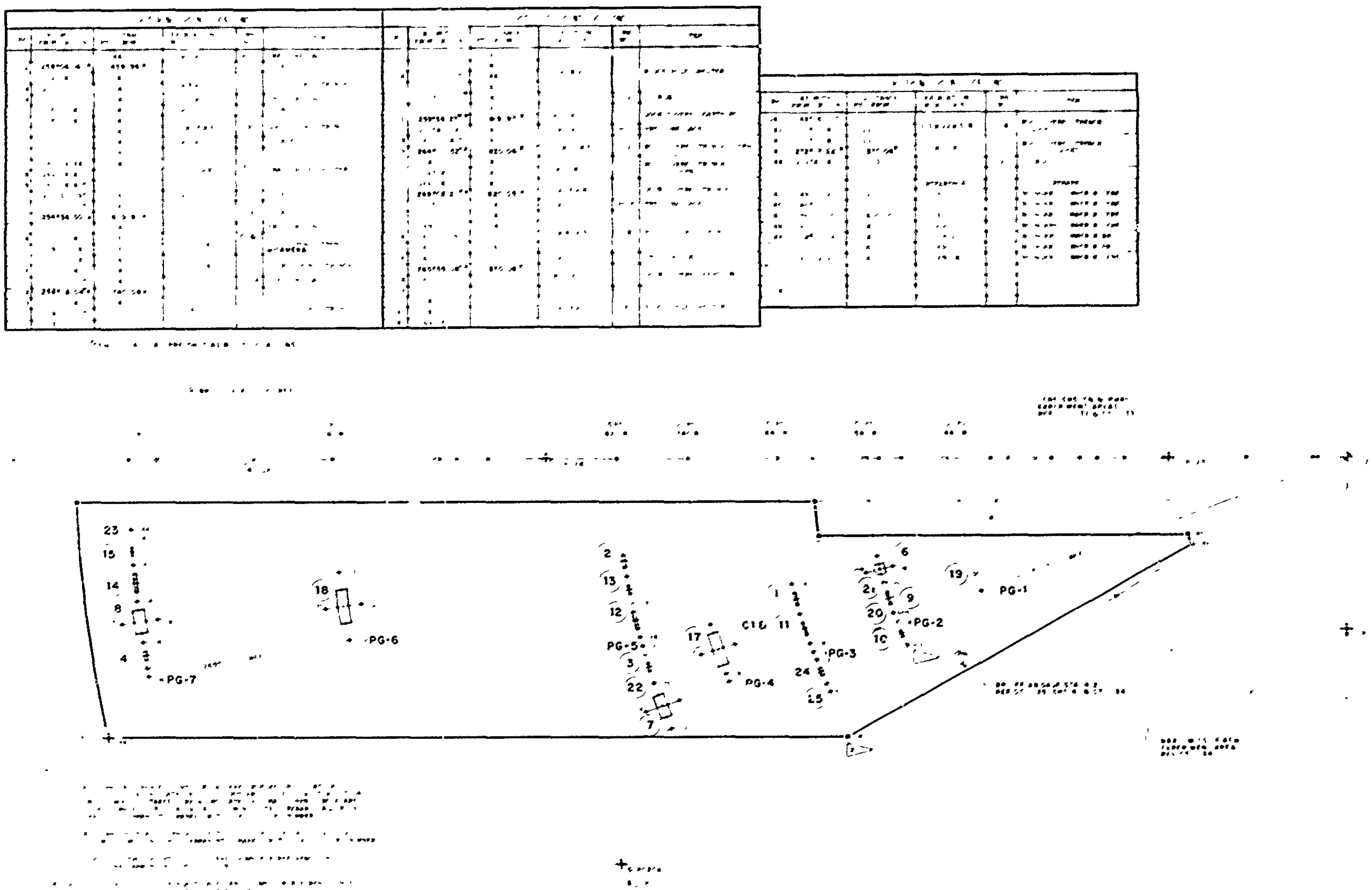


Figure 3-87. ORNL Experiment Layout, DICE THROW

Table 3-13. List of ORNL Test Shelters

Shelter	Type	Overpressure (psi)	Overpressure (kPa)
ORNL-1	Door Covered Trench	30	210
ORNL-2	Door Covered Trench	15	105
ORNL-3	Door Covered Earth-Roll	15	105
ORNL-4	Door Covered Earth-Roll	5	35
ORNL-5	Small Pole Shelter (Chinese Design)	100	700
ORNL-6	Small Pole Shelter (Chinese Design)	50	350
ORNL-7	Ridge Pole Shelter	15	105
ORNL-8	Ridge Pole Shelter	5	35
ORNL-9	Log Covered Trench	50	350
ORNL-10	Covered Trench (1/2 scale)	50	350
ORNL-11	Log Covered Trench	30	210
ORNL-12	Rug Covered Trench (open)	15	105
ORNL-13	Rug Covered Trench (1/2 scale - open)	15	105
ORNL-14	Rug Covered Trench (closed)	5	35
ORNL-15	Rug Covered Trench (1/2-scale - closed)	5	35
ORNL-16	Pole Covered Trench (Russian Design)	50	350
ORNL-17	Pole Covered Trench (Russian Design)	20	140
ORNL-18	Pole Covered Trench (Russian Design)	7	49

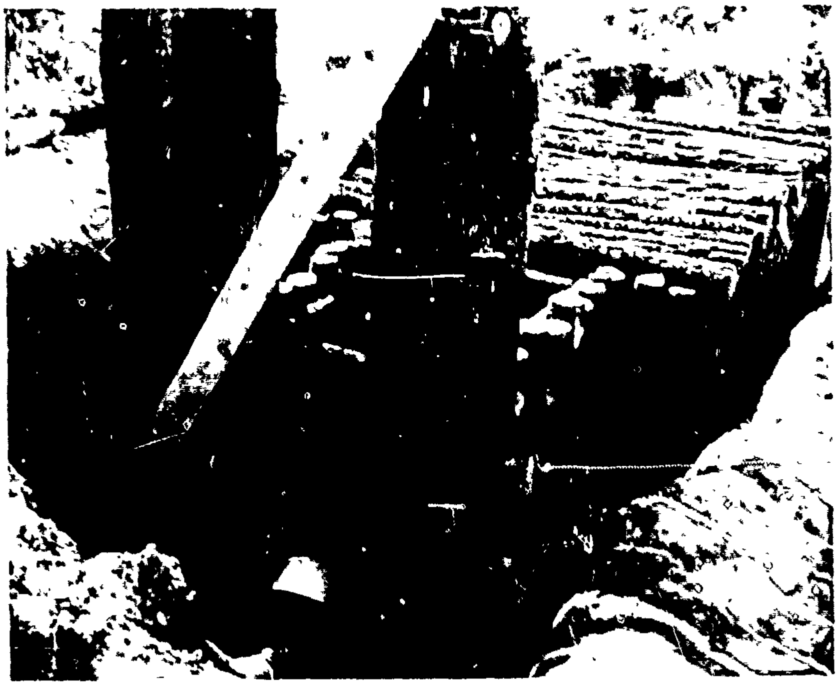


Figure 3-88. ORNL Expedient Shelter, Russian Design (Top Photo) and Chinese Design (Bottom Photo), DICE THROW

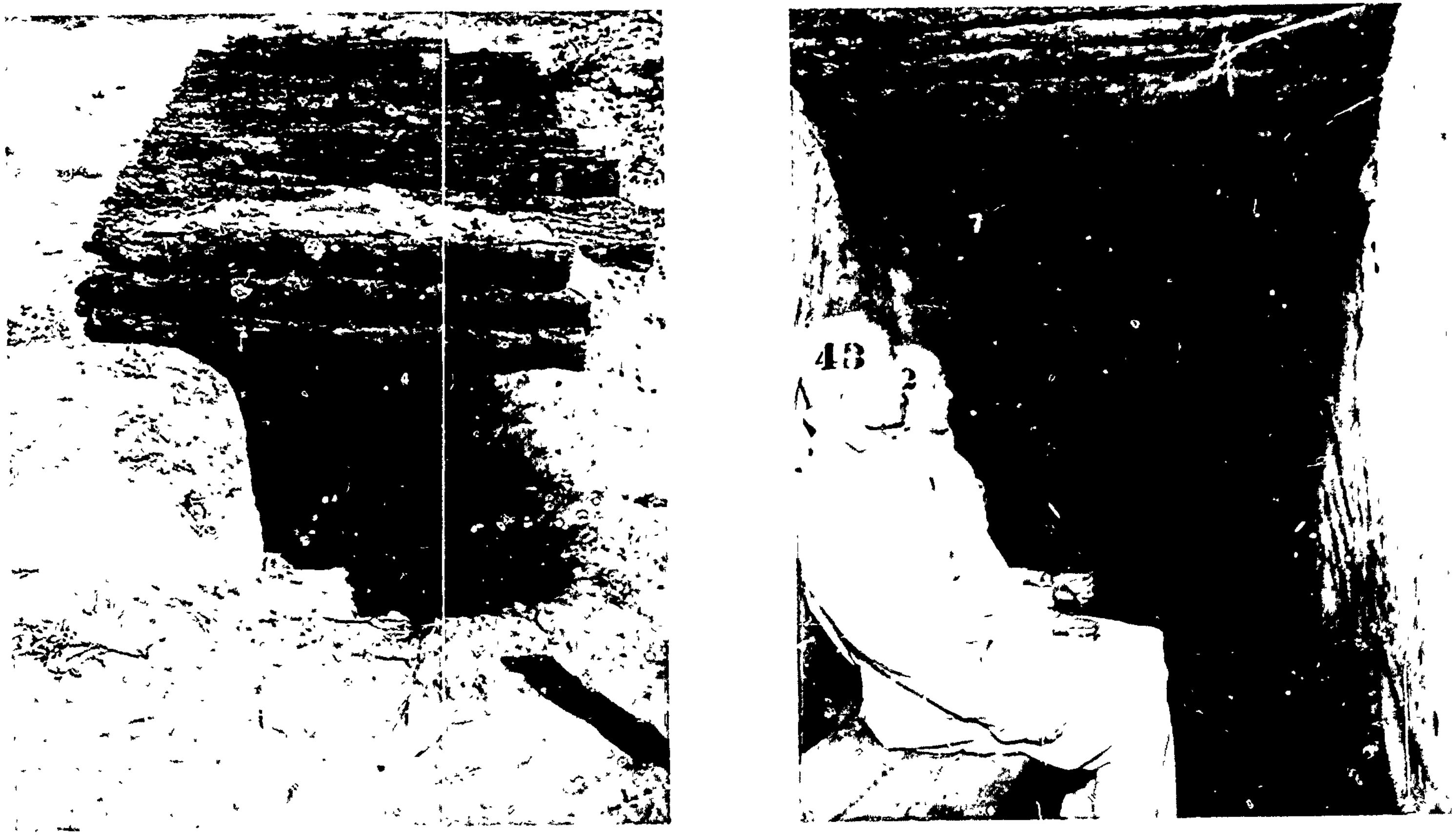


Figure 3-89. ORNL Expedient Shelters of American Design, DICE THROW

Figure 3-90. ORNL Expedient Shelter of American Design, DICE THROW

dummies in and around all key weapon systems. (2) Develop tactical nuclear doctrine for operation of U. S. Army weapons systems, validate current methodology used in the development of material nuclear survivability criteria and provide input into Project IVA (Integrated Vulnerability Assessment).

EXPERIMENT DESCRIPTION: Figure 3-91 and Table 3-14 provide detailed information of the test stations fielded on this experiment. Figure 3-92 depicts the test area. All instrumentation channels were recorded inside the ARMCOM bunker shown in Figure 3-93. Instrumentation dummies were located with the operationally-oriented systems. The dummies were installed and evaluated for damage by the Lovelace Foundation. The

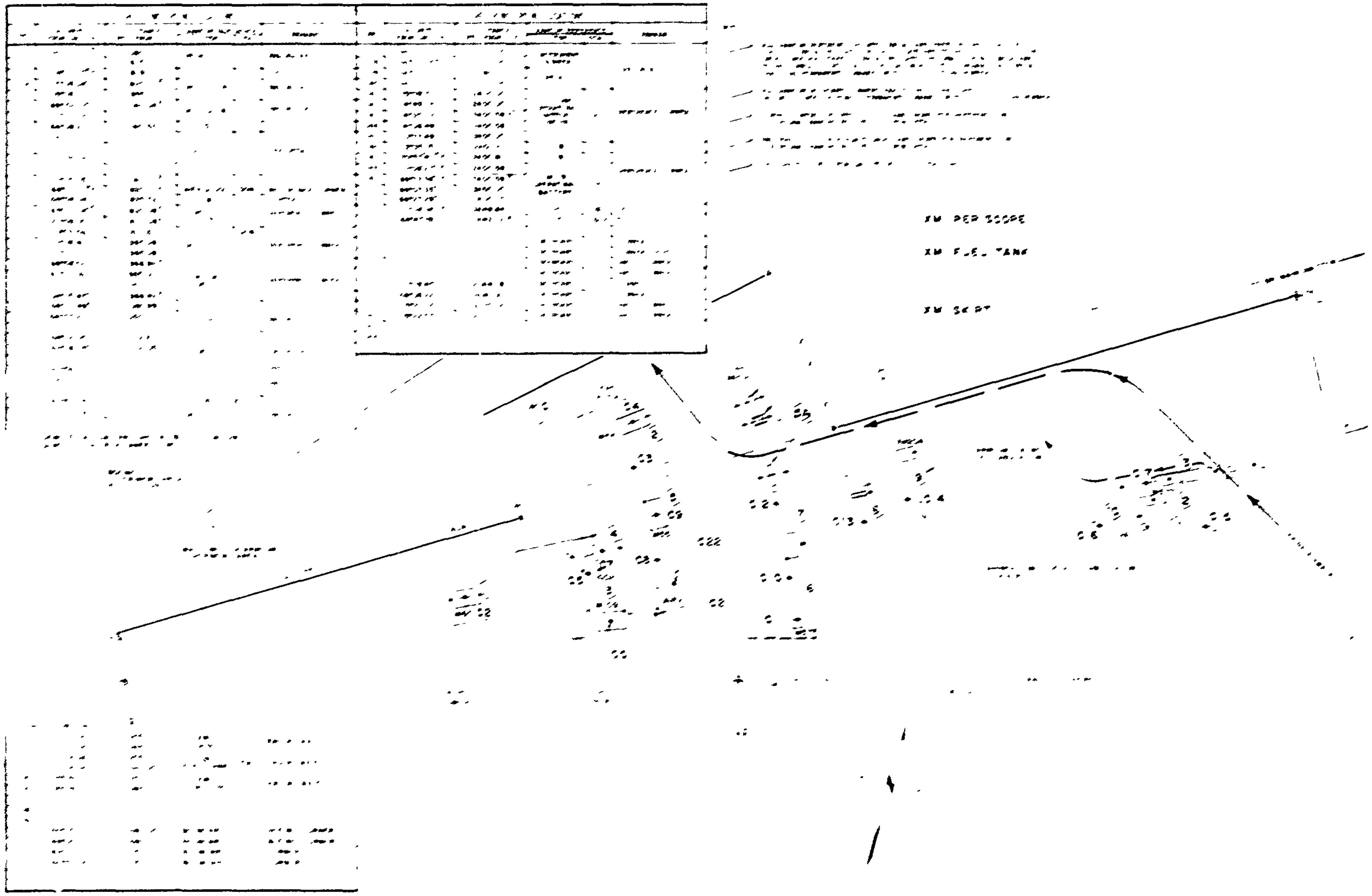


Figure 3-91. ARMCOM Experiment Layout, DICE THROW

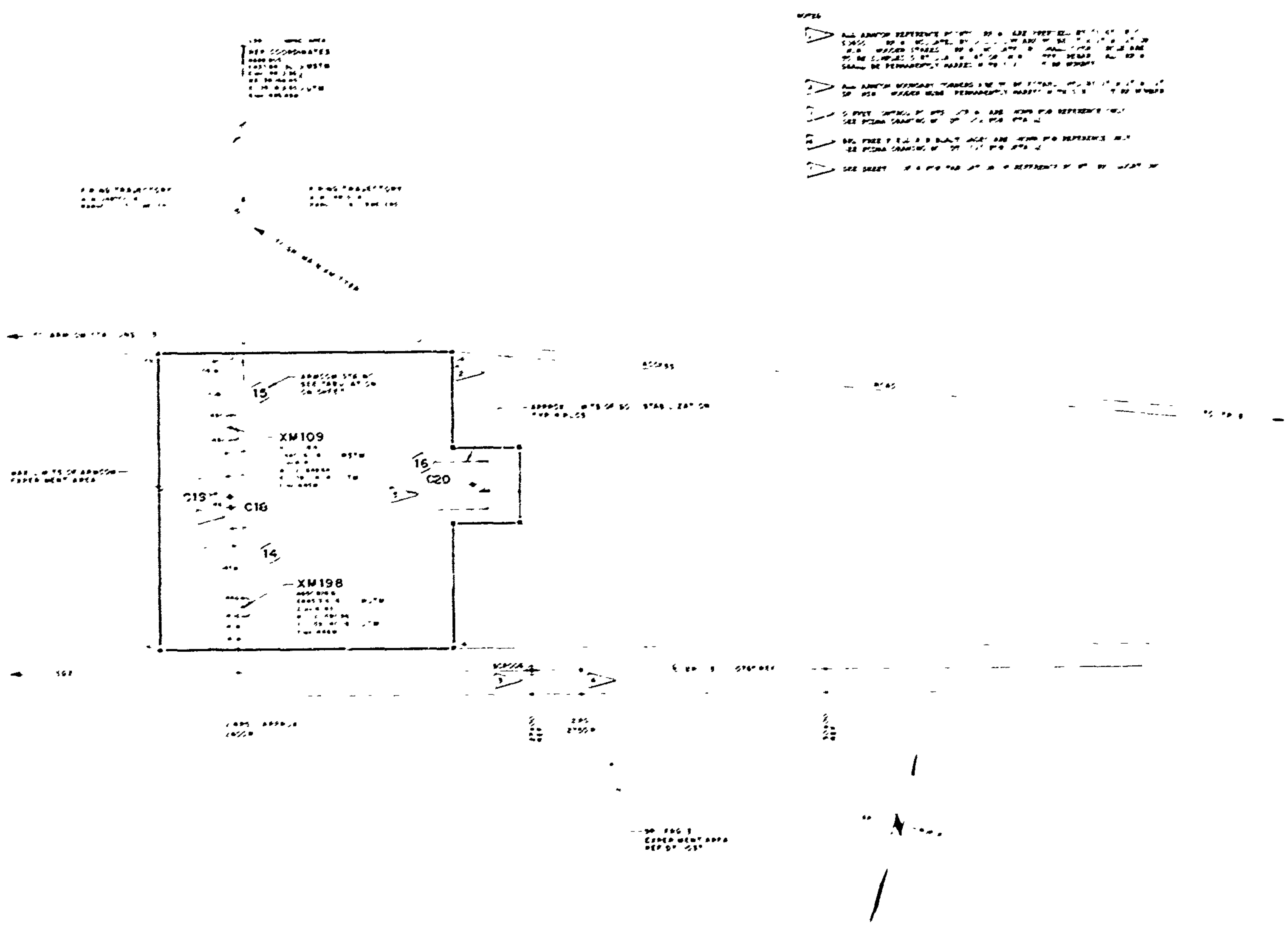


Figure 3-91. ARMCOM Experiment Layout, DICE THROW (Continued)

Table 3-14. ARMCOM Stations Listing

Description	Range (ft)	Range (m)	Overpressure (psi)	Overpressure (kPa)	Camera Number	Number Channels	Blast Orientation (degrees)	Number Dummies
M60 Main Battle Tank	570	173.7	45	315	1	8	0	1
M551 Sheridan (A)	680	207.3	25	175	2,3	8	0	1
M109 Self Propelled Howitzer	740	225.6	20	140	4,5	10	0	2
Underground Command Post	740	225.6	20	140	6	3	N/A	2
M551 Sheridan (B)	820	249.9	15	105	7,8	8	90	1
XM1 Mockups	820	249.9	15	105	7	1	N/A	0
M557 Communications Van	965	294.1	10	70	10,11	10	90	2
M110 Self Propelled Howitzer	965	294.1	10	70	9	13	90	2
CLGP	1050	320.0	8.4	58.8	12	5	0	0
XM204 Towed Howitzer	1112	338.9	7.5	52.5	14	7	0	0
Forward Observer	1370	417.6	5	35	13	1	0	1
VADS Radome Assembly	1370	417.6	5	35	13	4	0	0
Above Ground Command Post (M577 Deployed)	1370	417.6	5	35	13,15	2	N/A	2
Instrumentation Bunker	1370	416.6	5	35	None	1	N/A	0
Towed 155 Operational Battery (XM198)	2750	838.2	2	14	16	1	0	0
M109 Operational Battery	2750	838.2	2	14	17	1	0	0

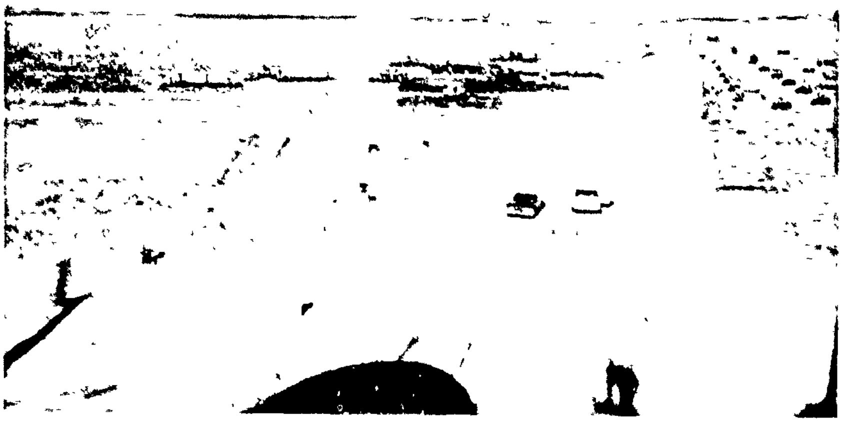


Figure 3-92. ARMCOM Experiment, Overview of ARMCOM Area Looking from GZ (Top Photo), ARMCOM Bunker Looking Toward GZ (Bottom Photo), DICE THROW

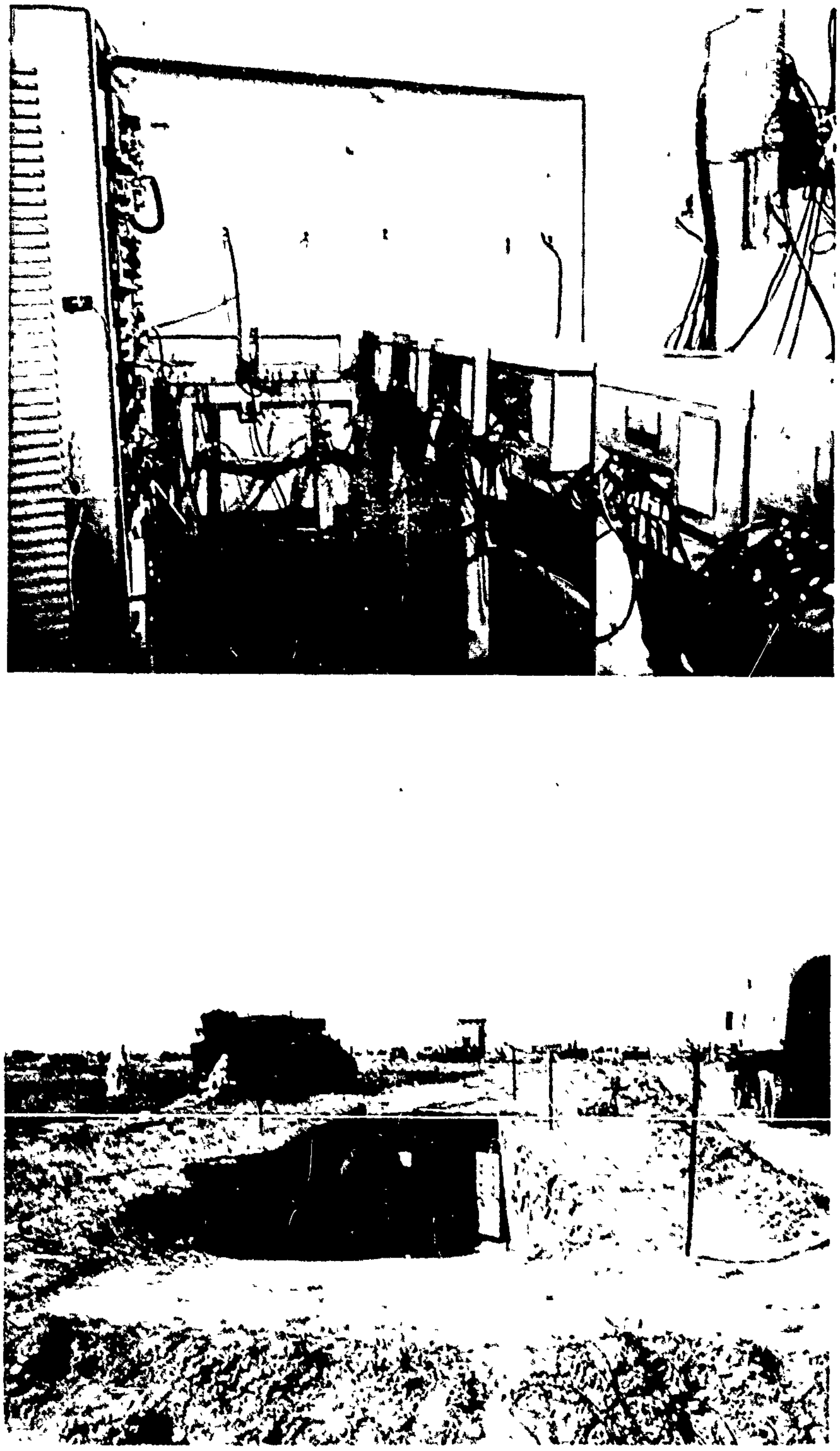


Figure 3-93. ARMCOM Instrumentation Bunker, Interior and Exterior View, DICE THROW

operationally-oriented systems were equipped with communications equipment and linked to the forward observer and/or the command posts. Communications were tested before and after the blast. The communications were a part of the ECOM network and monitored by ECOM.

A complete operational test of each system was completed prior to the event. Following the event, these same tests were to be performed. These tests included the firing of inert projectiles from the XM198 and M109 howitzers. Ten-lb (4.54-kg) inert rounds were fired at the target area as shown in Figure 3-94. The same tests were to be repeated following the DICE THROW event to determine the effects of the blast on the howitzers. Military personnel, as well as civilian engineers, were employed for these checkouts. Refer to Figures 3-95 through 3-98 for photographs of the test vehicles.

21. Sandia Laboratory Albuquerque (SLA)

(a) TITLE: Airblast Damage Predictions, DNA Project #122

PROJECT OFFICER: Mr. J. Reed (505) 264-3042

OBJECTIVES: (1) Provide airblast damage predictions on event day to the Test Group Director for consideration in making final firing decision. (2) Make microbarograph measurements from several New Mexico communities in the vicinity of the test site and on WSMR.

EXPERIMENT DESCRIPTION: The blast wave could, under strong atmospheric propagation conditions, cause some window breaking and plaster damage to the 90-mile (140-km) distance. Since this range contains Socorro, Alamogordo, Las Cruces and Truth or Consequences (T or C), a weather-watch was instituted to determine what propagations could be expected at shot time and provide for delays in case such extreme conditions were encountered. Refer to Table 3-15.

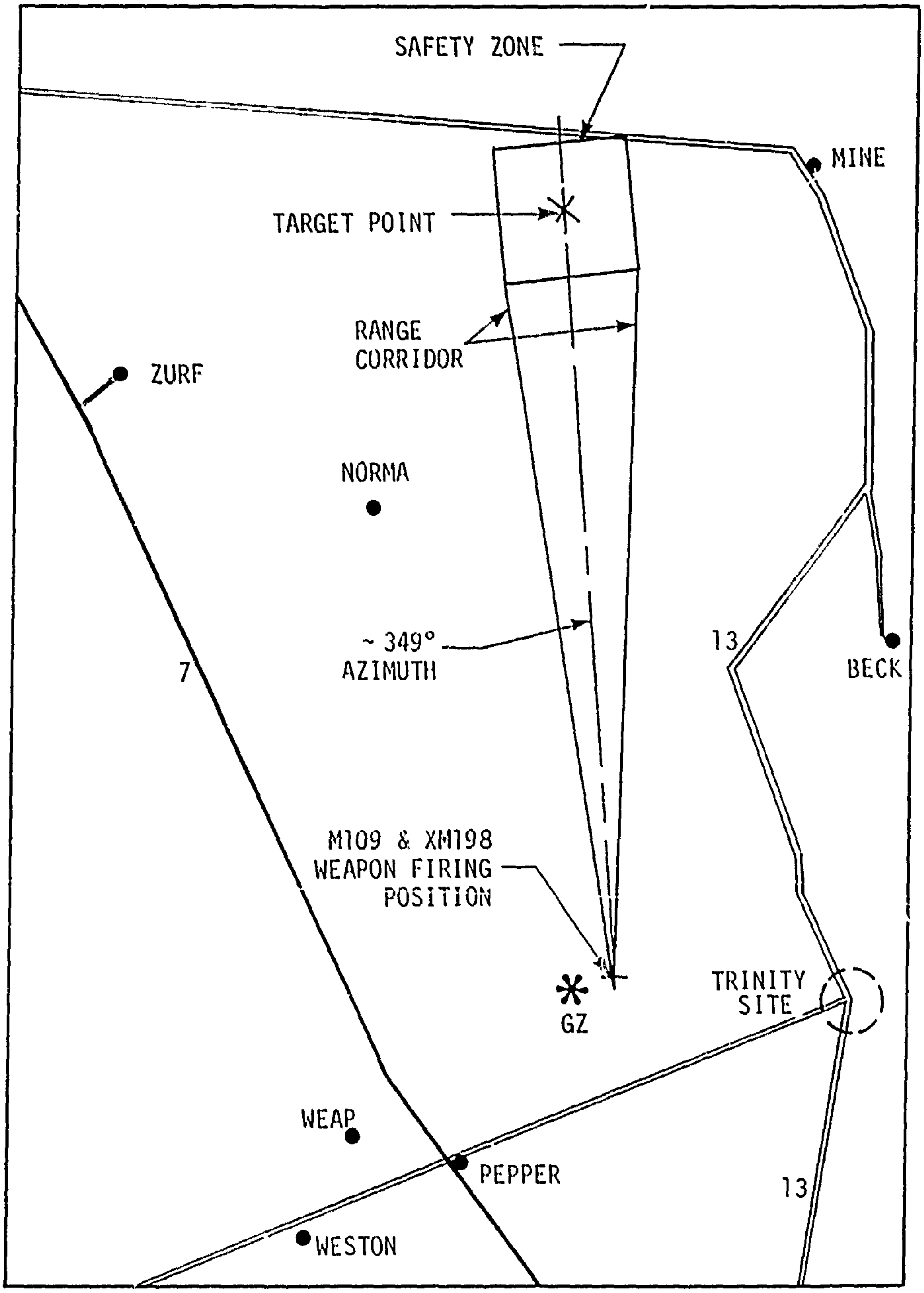
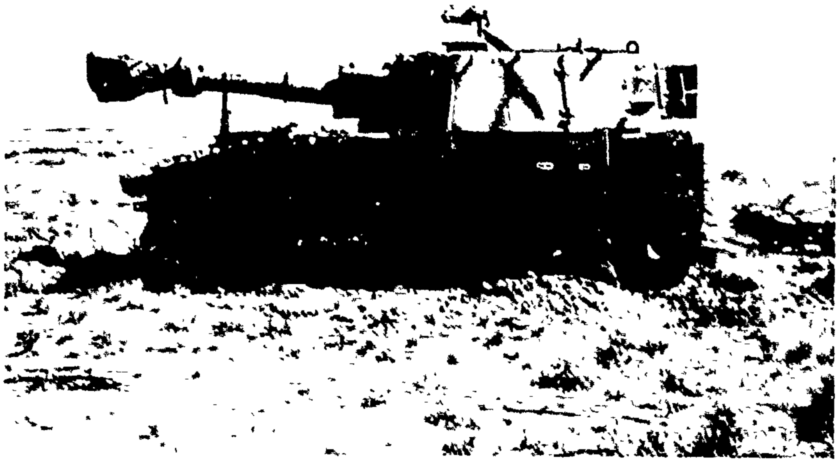


Figure 3-94. Howitzer Firing Target, DICE THROW



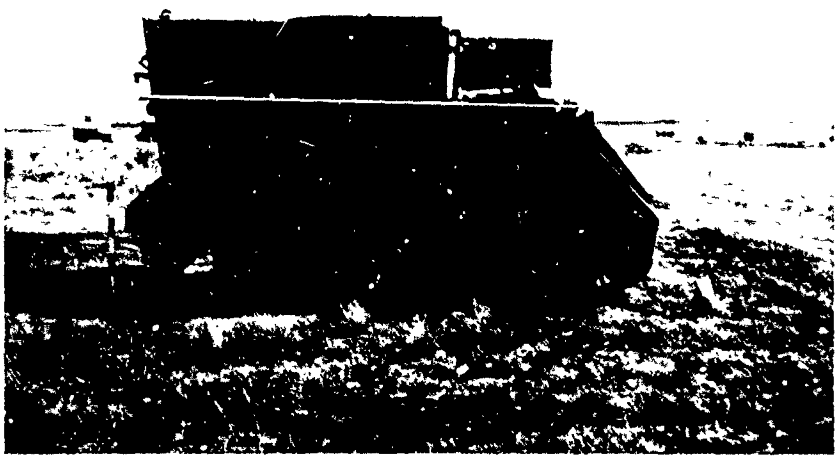
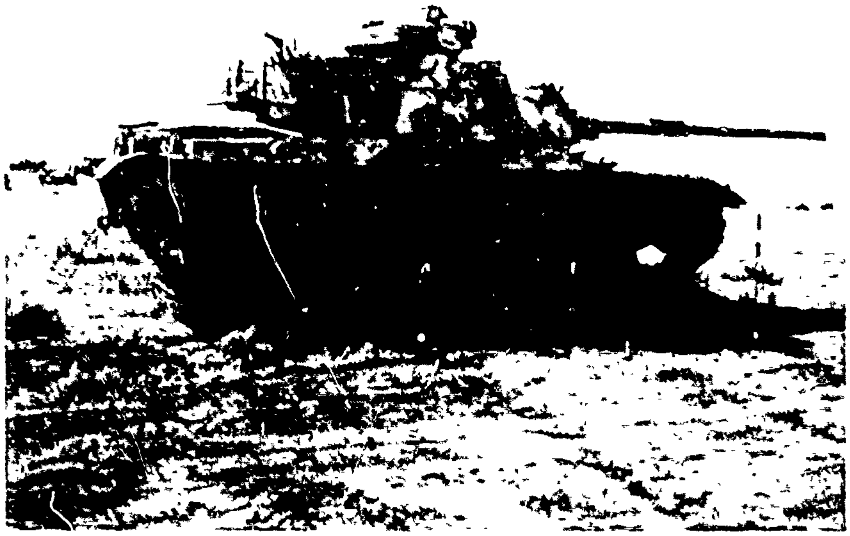


Figure 3-95. ARMCOM Experiment, M109 (Top Photo) and M577 (Bottom Photo), DICE THROW



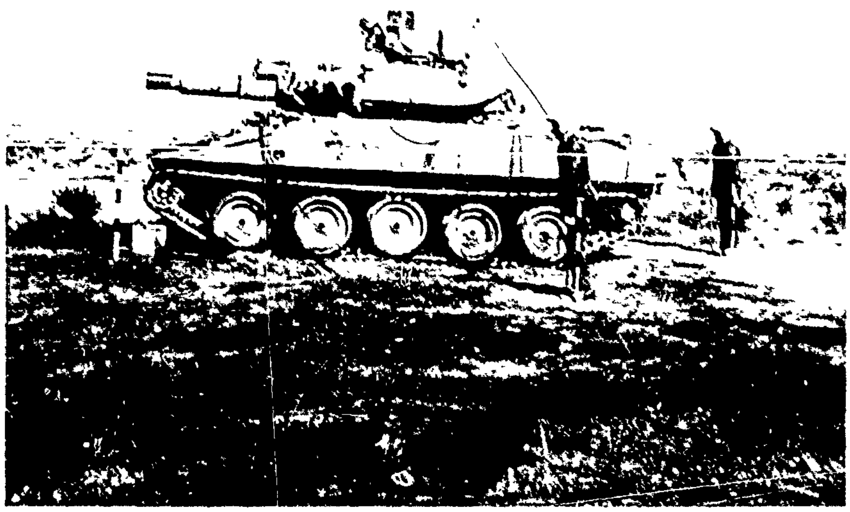
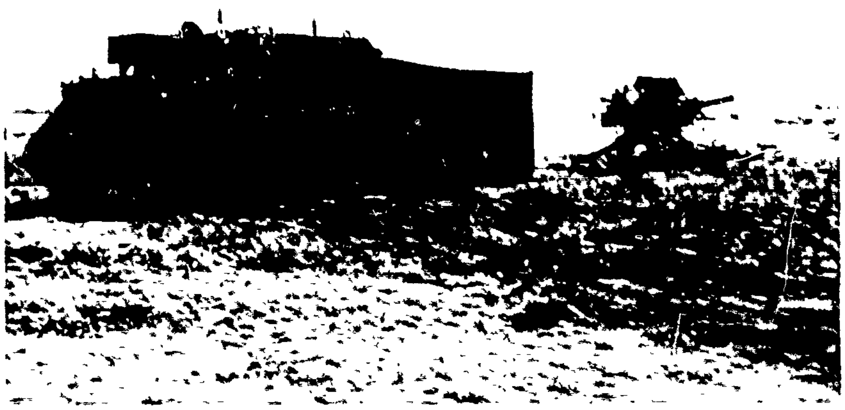


Figure 3-96. ARMCOM Experiment, M60 (Top Photo) and M551 (Bottom Photo), DICE THROW



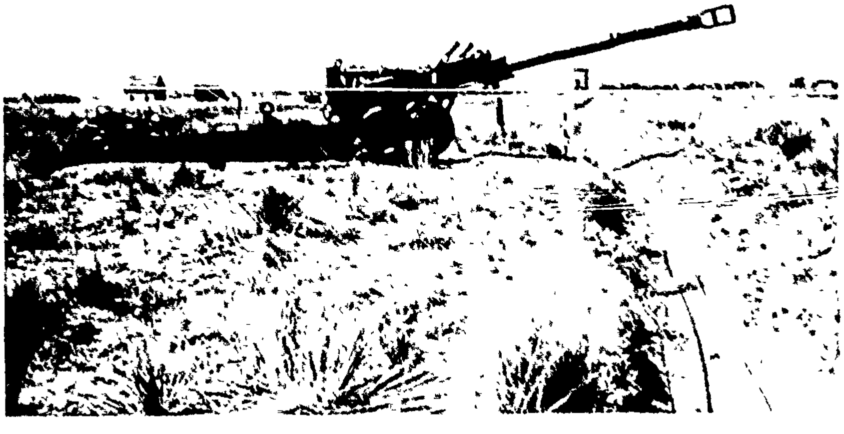


Figure 3-97. ARMCOM Experiment, 577 Communication Post and V.A.D.S. (Top Photo), XM 198 Howitzer (Lower Photo), DICE THROW

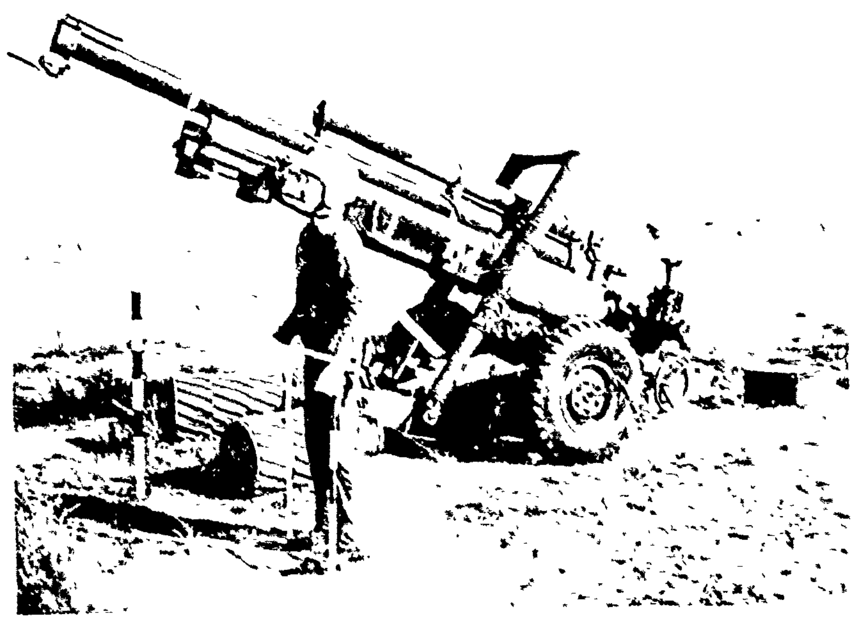


Figure 3.98. ARMCOM Experiment, XM 204 Howitzer,
DICE THROW

Table 3-15. SLA Predicted Peak-to-peak Amplitudes, P_k* Pascals, and Expected Number of Window Panes Broken, N, Under Various Atmospheric Propagation Conditions

Community	Estimated Population	Distance (km)	Gradient		Standard		Inversion		Focusing	
			P_k*	N	P_k*	N	P_k*	N	P_k*	N
Stallion Center	100	19	195	0	840	0	2500	6	4100	25
San Antonio	200	41	41	0	340	0	1000	1	1660	4
Socorro	5,900	53	24	0	253	1	750	13	1220	51
Albuquerque	270,000	155	3	0	70	1	206	17	345	70
Mountainaire	800	94	8	0	103	0	380	0	630	1
Corona	200	103	6	0	114	0	340	0	560	0
Carrizozo	900	60	19	0	230	0	650	1	1060	5
Tularosa	2,700	81	10	0	150	0	450	1	730	6
Alamogordo	24,000	100	7	0	120	0	350	0	670	38
T or C	4,700	89	8	0	138	0	400	2	650	7

Balloon launches were made at H-4, H-2, H-1 and H hours. Sound velocity versus height structures were calculated for the four general directions toward vulnerable communities. Strong airblast propagation could be expected where the upper-air sound velocities exceeded surface-level sound velocities, causing refractive ducting, or even focusing, of the blast wave along the ground.

Observations and propagation predictions were telephoned to the Test Director at H-3-1/4, H-1-1/2 and H-1/4 hours, for consideration in countdown decision-making.

(b) TITLE: Nuclear Blast Detection System (NBDS)

PROJECT OFFICER: Mr. R. Glazer

OBJECTIVE: Utilize NBDS equipment to measure the azimuth and time history of an optical event and thereby demonstrate capabilities of the NBDS.

EXPERIMENT DESCRIPTION: The equipment used consisted of a tripod-mounted sensor station, a prototype junction box, a hand-held display, hard-wired communications, van-mounted Central Processing Console (CPC) and a motor-generator set. The equipment was located at WEAP site, 13,280 ft (4,048 m) from ground zero. In order to make time-history and azimuth measurements, certain modifications were required to prevent system rejection. A dummy station was located in the test-bed area. (Refer to Figures 3-99 and 3-100.)

22. 7th Special Forces Group (SFG)

TITLE: FTX Orbit Quiver

PROJECT OFFICER: Cpt. A. Wojcicki, USA

a) OBJECTIVES: Determine blast response of radio/antenna combinations and determine attenuation of RF signal.

EXPERIMENT DESCRIPTION: A total of 36 radio/antenna combinations were tested prior to the event. These included Di-pole, inverted "V", inverted "L", loop, slant wire and buried multi-wave long-wire antennas connected to the

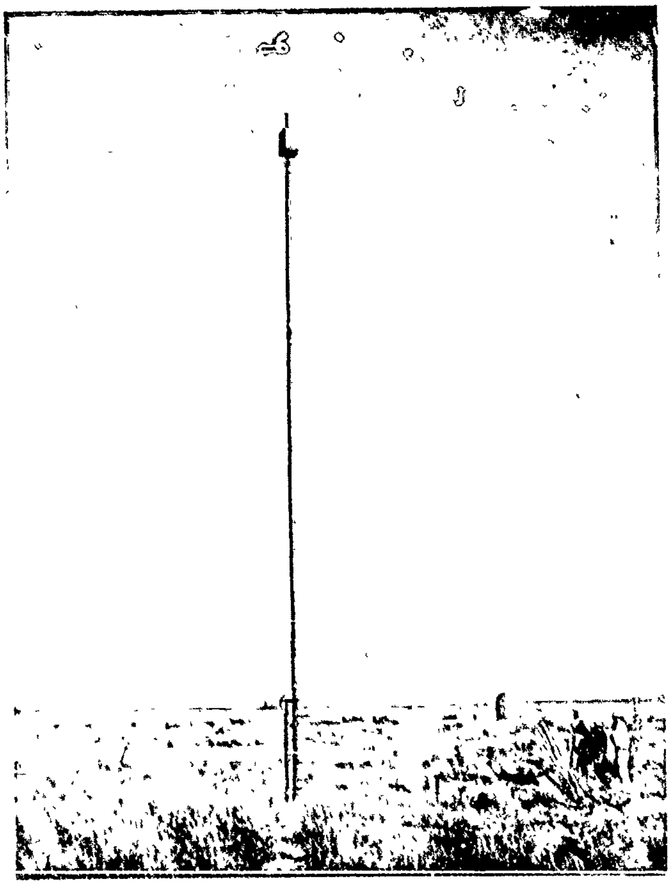
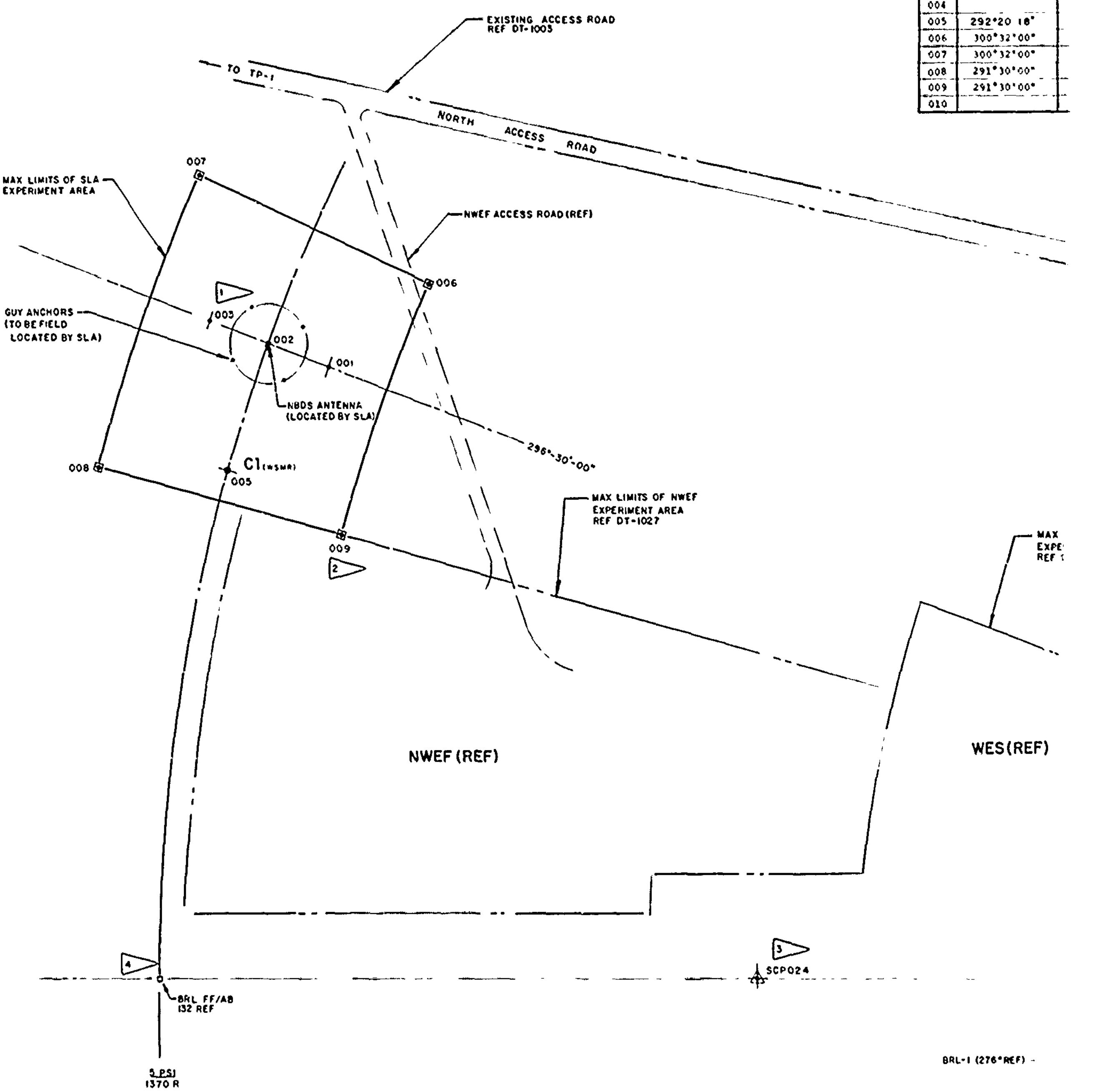


Figure 3-99. SLA Passive NBDS Located in Test Bed Area, DICE THROW



RP	AZIMUTH (FROM GRID N)
001	296°30'00"
002	296°30'00"
003	296°30'00"
004	
005	292°20 18"
006	300°32'00"
007	300°32'00"
008	291°30'00"
009	291°30'00"
010	

Figure 3-100. SLA Experiment Layout, DICE THROW

REFERENCE POINT LOCATIONS				
RP	AZIMUTH (FROM GRID N)	DISTANCE (FT FROM SGZ)	SLA/NBDS REFERENCE	REMARKS
001	296°30'00"	1320.00		RADIAL AXIS
002	296°30'00"	1370.00		CENTER
003	296°30'00"	1420.00		RADIAL AXIS
004				
005	292°20 18"	1358 97	C1(700504)	CNTR CAMERA LENS
006	300°32'00"	1270.00	BOUNDARY	CORNER
007	300°32'00"	1470 00	BOUNDARY	CORNER
008	291°30'00"	1470 00	BOUNDARY	CORNER
009	291°30'00"	1270.00	BOUNDARY	CORNER (NWEF)
010				

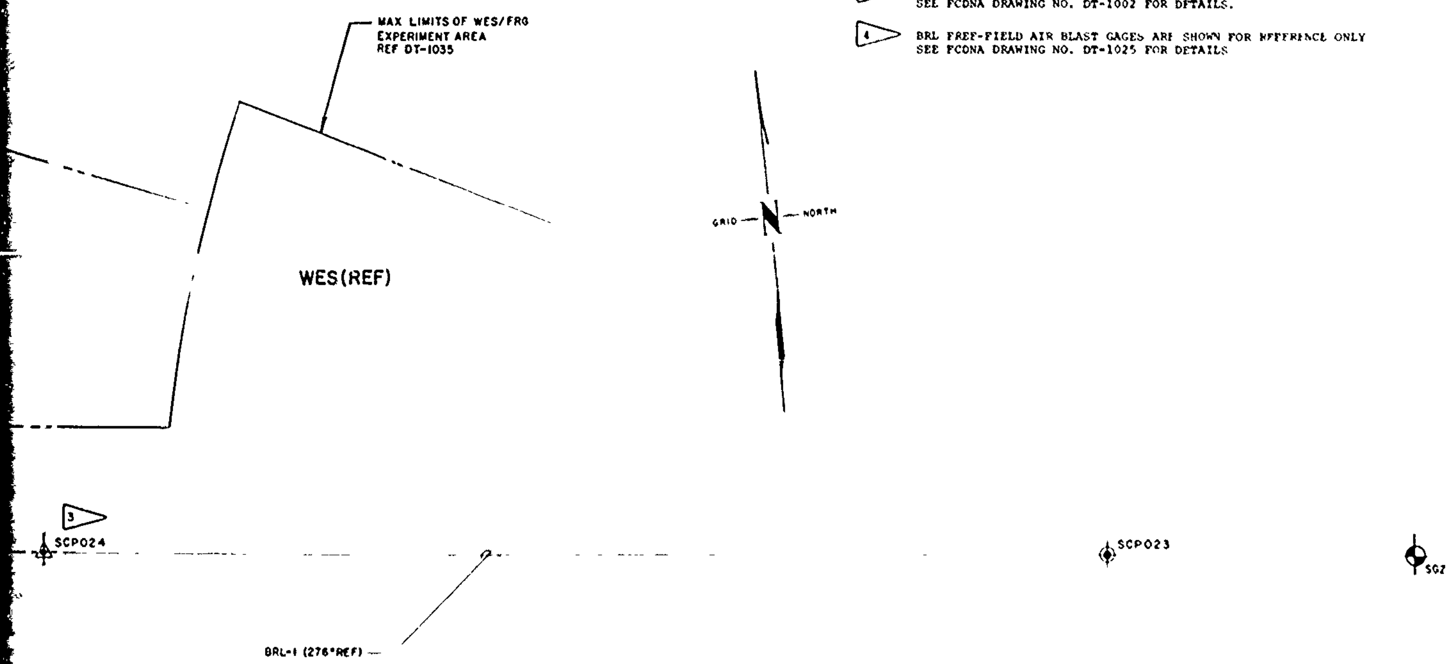
NOTES:

1. ALL SLA/NBDS REFERENCE POINTS (RP's) ARE PREFIXED BY "332", E.G., 332001. RP's INDICATED BY SOLID DOT ARE TO BE 1" x 2" x 12" DP (MIN) WOODEN STAKES. RP's INDICATED BY SMALL OPEN CIRCLE ARE TO BE DIMPLED 5/8" DIA. x 24" DP (MIN) STEEL REBAR. ALL RP's SHALL BE PERMANENTLY MARKED WITH SIX DIGIT RP NUMBER.

2. ALL SLA/NBDS BOUNDARY CORNERS ARE TO BE ESTABLISHED BY 2" x 2" x 12" DP (MIN.) WOODEN HUBS, PERMANENTLY MARKED WITH SIX DIGIT RP NUMBER.

3. SURVEY CONTROL POINTS (SCP's) ARE SHOWN FOR REFERENCE ONLY. SEE FCDNA DRAWING NO. DT-1002 FOR DETAILS.

4. BRL FREE-FIELD AIR BLAST GAGES ARE SHOWN FOR REFERENCE ONLY SEE FCDNA DRAWING NO. DT-1025 FOR DETAILS



HROW

2

AN/GRC-109 and AN/PRC-74B radios. From these combinations, the five providing the most reliable communications were tested for blast/shock response at approximately 5000 ft (1524 m) from GZ. The data obtained from this experiment will be used to formulate or modify Special Forces Communications doctrine for operations in desert and nuclear environments.

b) OBJECTIVE: Provide the 7th Special Forces Group (SFG) personnel with experience of operating in an environment of simulated nuclear combat.

EXPERIMENT DESCRIPTION: Troop training commenced with a parachute infiltration of 17 personnel into Drop Zone DUSTY (WSMR coordinates 674,222 N 436,218E) on 3 October. Exercise participants performed direct-action missions on targets in the area of operations during the periods 4 October to 6 October, and 7 October to 9 October. On test day, the exercise participants performed a radio transmission experiment. Two 2-1/2-ton trucks with trailers were utilized for essential support during the exercise and for transportation of exercise participants to Holloman AFB at conclusion of the exercise.

23. Stanford Research Institute (SRI)

TITLE: RF Transmission Experiment, DNA Project #52

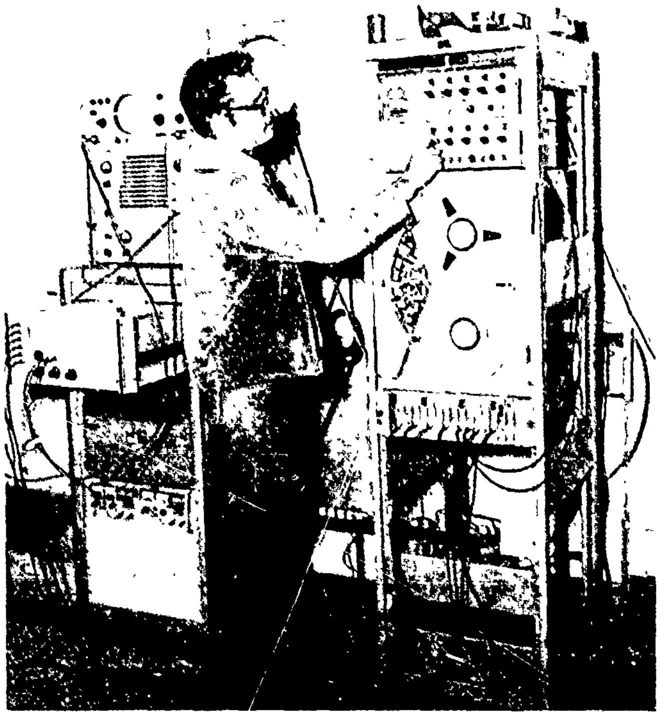
PROJECT OFFICER: Dr. A. Burns (415) 326-6200, -3625

OBJECTIVE: Measure the effects of dust and debris on signals passing through the cloud lofted by the detonation.

EXPERIMENT DESCRIPTION: This experiment was designed to measure the effects on the amplitude, phase and angle-of-arrival of UHF and microwave signals propagating through the dust cloud (stem, cap and sweep-up cloud) lofted by the explosion. The transmission experiment used coherent UHF (379, 413, 424 and 447 MHz), L- (1.24, 1.27 and 1.3 GHz), S- (2.9 GHz) and X-band (8.9 and 10.2 GHz).

It consisted of a multifrequency, phase-coherent transmitter located approximately 2067 ft (630m) from the detonation, a multifrequency receiver and interferometer located on the extension of the radial passing through ground zero from the transmitter, and a relay station to pass a phase-reference signal from the transmitter to the receiver along a path clear of the explosion. A 20-ft (6.1-m) earth mound (refer to Figure 3-101) which protects the transmitter and associated electronic equipment was required at the transmitter location. A second transmitter was placed in a building (Bldg. 32200) on the ridge of the Oscura Range to provide a RF path passing about 656 ft (200 m) directly over ground zero (refer to Figure 3-102). This second transmitter was phase-locked to the first by means of an L-band link. The distance from the main transmitter to the azimuthally-separated receiving antennas was about 2.5 - 3.1 miles (4 - 5 km). A 7.5-ft (2.3-m) high, 100-ft (30.5-m) long clutter fence in front of each of the receiving antenna systems was needed to reduce or eliminate ground reflection and reflections from equipment and structures associated with

Figure 3-101. SRI Main Transmitter in the Test Bed Area, DICE THROW



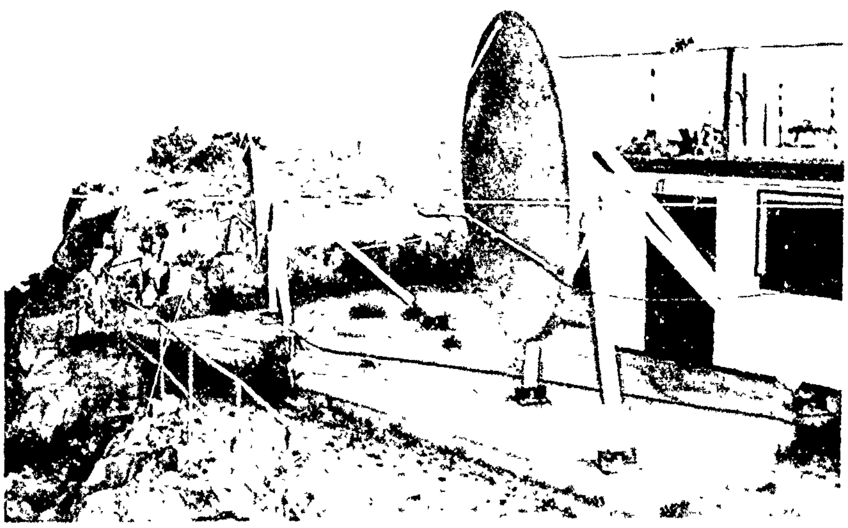


Figure 3-102. SRI Remote Transmitter Located on North Oscura Peak, DICE THROW

the other experiments. It was very important that the lines-of sight between transmitting and receiving antennas were unobstructed.

Vans contained the receiving equipment, and building 32200 accommodated the remote transmitter. The phase-reference repeater consisted of a 20-ft (6.1-m) pole with antennas and an electronics package attached. Refer to the photograph in Figure 3-103. The electronics for the main transmitter were protected by sheltering them in a metallic (CONEX) box partly buried in the back of the mound elevating the main transmitter antenna system. Refer to the experiment layout in Figure 3-104.

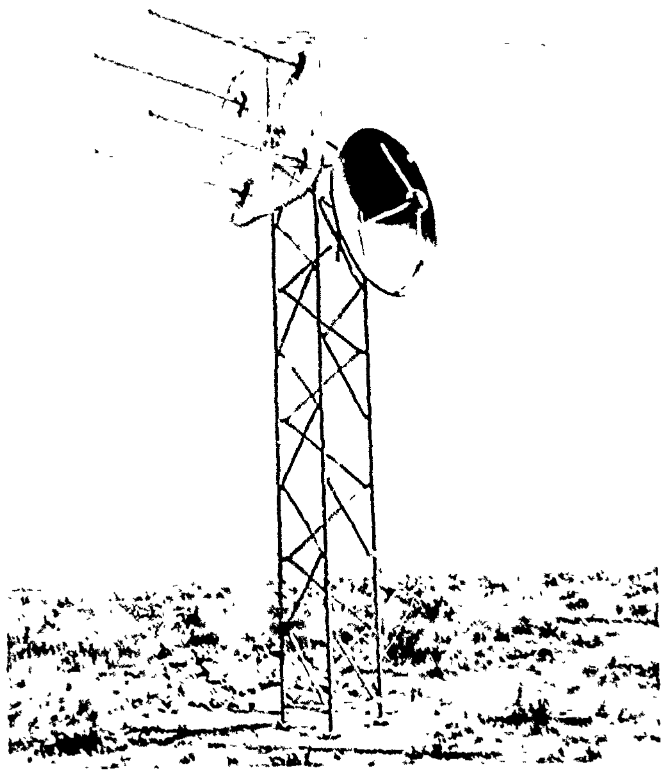
24. Strategic Air Command (SAC)

TITLE: B-52 Observation of DICE THROW, DNA Project #173

PROJECT OFFICER: Maj. B. Stephan (402) 331-3670, -3189

OBJECTIVE: Demonstrate the capability to perform the damage assessment/strike mission under a variety of limitations and evaluate the Electro-Optical Viewing System (EVS) against a high-explosive detonation.

EXPERIMENT DESCRIPTION: Two SAC B-52 aircraft, maintaining five-minute separation, entered the WSMR from the north at or below 10,000 feet (3,048 m) MSL. The lead aircraft entered a holding orbit of approximately T-22 minutes. The second aircraft maintained a five-minute separation throughout the operation. The mission of both aircraft was to exercise on-board equipment against the detonation and to perform RBS sorties against designated targets in the test area. Radar plotboard tracking of each B-52 was performed by Stallion Range Control from 10 nmi (18.5 m) north of GZ to the GZ for simulated bomb runs scoring from T-20 minutes until mission completion. Figure 3-105 depicts two of the targets for the mission, a simulated hangar in the top photo and the crater in the lower photo. An additional simulated hangar acted as a damaged target.



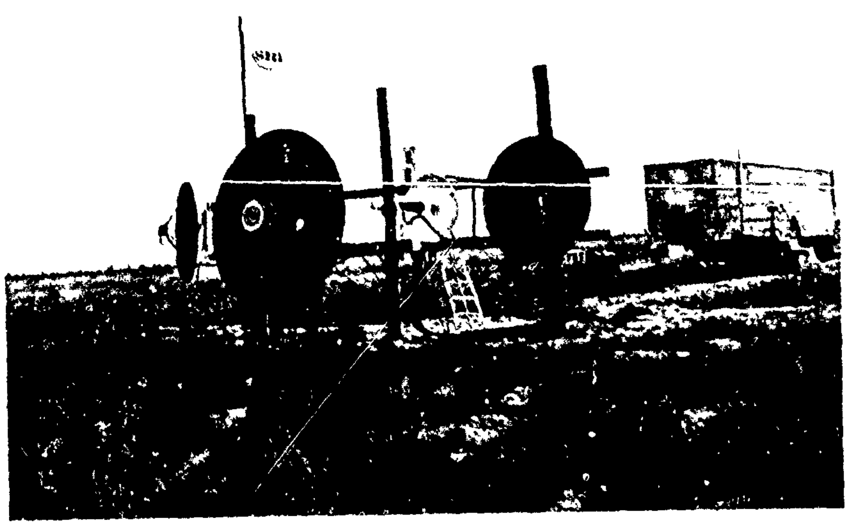


Figure 3-103. SRI Repeater Station (Top Photo), SRI Receiving Station (Bottom Photo), DICE THROW

NOTES
1 - ALL ANTENNAS AND ASSOCIATED MOUNTING HARDWARE TO BE FURNISHED BY SRI.
2 - ALL SRI REFERENCE POINTS (RP'S) ARE PREFIXED BY 052: E.G., 052001.

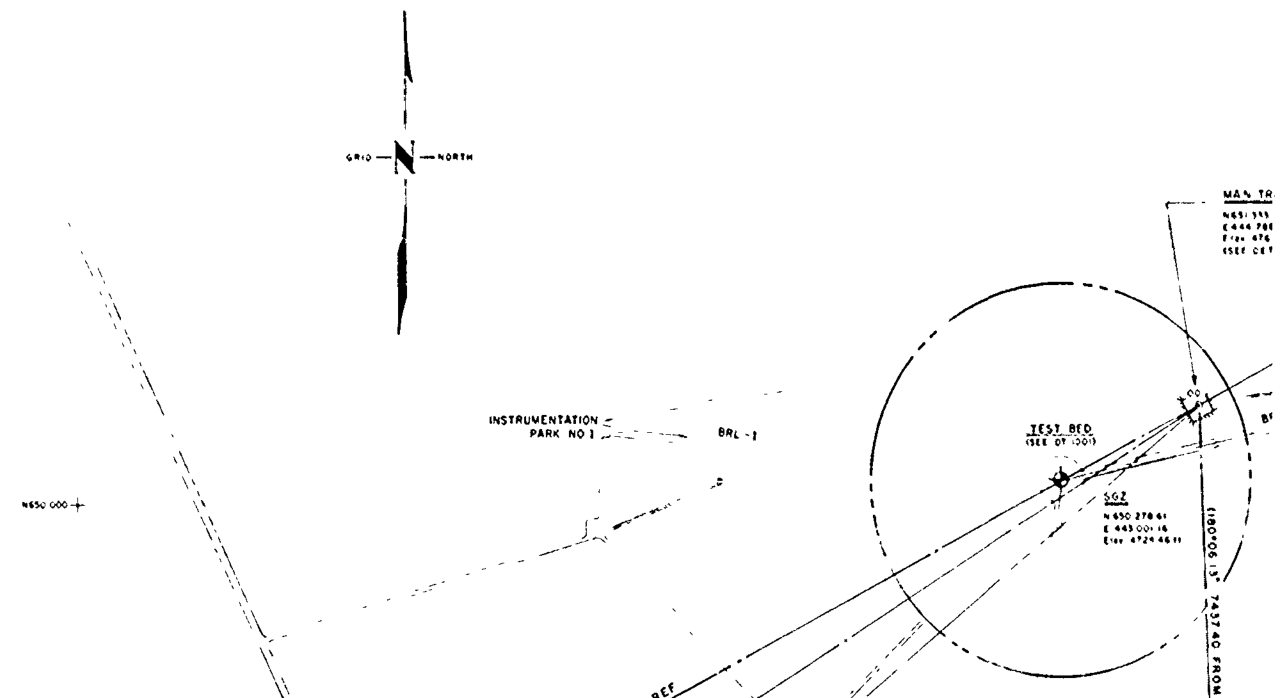
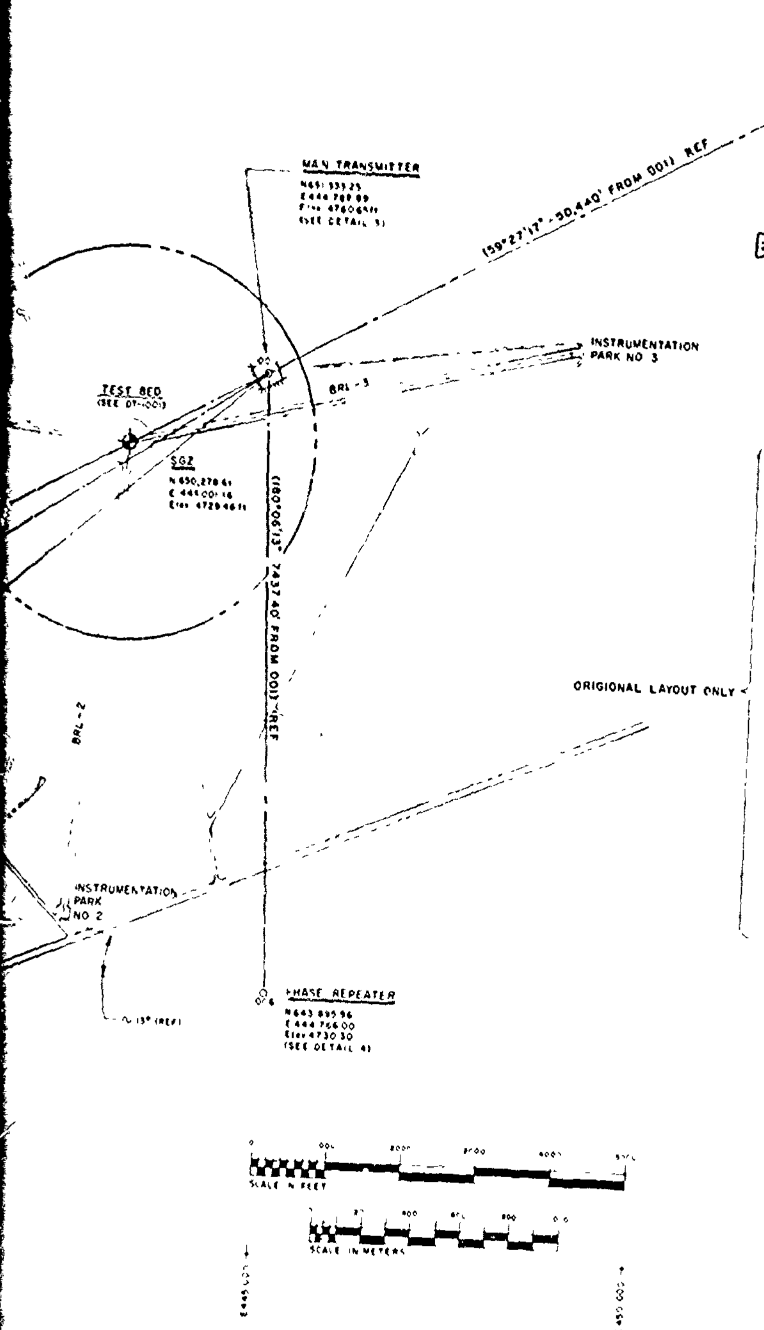


Figure 3-104. SRI Experiment Layout, DICE THROW



PLANNED EXPERIMENT LOCATIONS

RP	AZIMUTH (FROM GRID N)	DISTANCE (FT. FROM SGZ)	DIMENSIONS (W x L x H)	ITEM (STA., DESC., REMARKS)
001	59°27 44	2076 36	SEE DETAIL 1	MAIN TRANSMITTER
002	59°27'17"	32,516.70	SEE DETAIL	REMOTE TRANSMITTER
003	239°27'17"	12,999 68	SEE DETAIL 3	MAIN RECEIVER
004	235°13'55"	12,714.78	SEE DETAIL 3	RECEIVER NO. 2
005	226°55'59"	13,712.90	SEE DETAIL 3	RECEIVER NO. 3
006	164°32 37"	6623 79	SEE DETAIL 2	PHASE REPEATER
007				
008				
009				
010	227°45'26"	14,088 48		
011	227°45'36"	14,292 48		BOUNDARY
012	228°09'40"	14,292.48		BOUNDARY
013	228°09'50"	14,088 48		BOUNDARY
014	235°26'35"	13,326 48		BOUNDARY
015	235°26'46"	13,520 48		BOUNDARY
016	235°52'12"	13,520 48		BOUNDARY
017	235°52'23"	13,316 48		BOUNDARY
018	239°13'54"	12,836 10		BOUNDARY
019	239°14'10"	13,102.10		BOUNDARY
020	239°40'24"	13,102 10		BOUNDARY
021	239°40'40"	12,836 10		BOUNDARY
022				BOUNDARY
023				BOUNDARY
024				BOUNDARY
025				BOUNDARY
026				BOUNDARY
027	56°32'39"	1,969 47		BOUNDARY
028	62°21'55"	1,969 47		BOUNDARY
029	56°48'45"	2,269 24		BOUNDARY
030	62°05'49"	2,269 24		BOUNDARY
031	162°45'05"	7,236 13		BOUNDARY
032	163°08'52"	7,236 13		BOUNDARY
033	162°45'10"	7,286 13		BOUNDARY
034	163°00'40"	[illegible]		BOUNDARY
035				BOUNDARY
036				

2

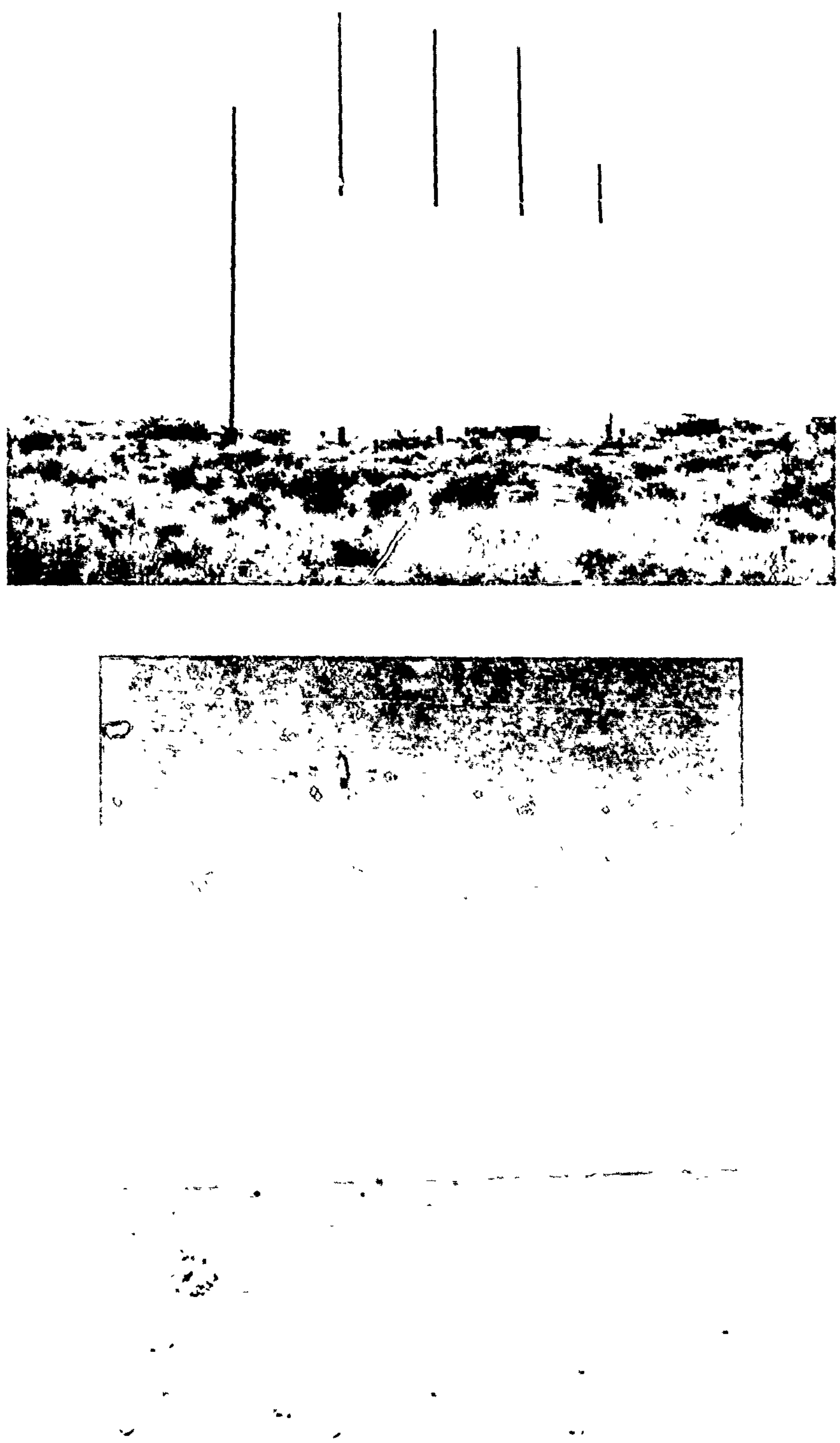


Figure 3-105. SAC Targets used on DICE THROW, Photo-Simulated Structure (Top Photo) and a B-52 over the crater (Bottom Photo), DICE THROW

Also included in the experiment was a simulated runway 75 ft (22.9 m) wide and 5000 ft (1524 m) long. The runway was graded and cleared of vegetation (refer to Figure 3-106).

25. Sweden/CERF

TITLE: Personnel Shelter, DNA Project #169

PROJECT OFFICER: Dr. G. Lane/CERF (505) 264-4644

OBJECTIVE: Verify the Army Shelter survivability overpressure in order to establish a standard personnel shelter design.

EXPERIMENT DESCRIPTION: (Refer to Figure 3-107 for the experiment layout.) The Swedish Government, represented by the Royal Swedish Fortification Administration (RFA), fielded two Army underground personnel shelters (known as "The Group Helmet") at expected overpressures of 55 psi (385 kPa) and 100 psi (700 kPa). CERF was responsible for construction, monitoring, instrumentation and reporting of the project.

A basic, life-like human dummy (with accelerometer) was placed in each shelter containing six pressure gages with one pressure gage outside. Figures 3-108 and 3-109 are photographs of the shelters during construction and after completion, respectively.

26. United Kingdom (UK)/Admiralty Surface Weapons Establishment (ASWE)

TITLE: Blast Response of Slatted Antenna Integrated Masts, Vented Radomes and Whip Antennas, DNA Project #110

PROJECT OFFICER: Mr. K. Feltham--Attn: British Embassy, ACOW (Mr. W. Sellek) Washington, D.C. (202) 462-1340, ext. 2511

OBJECTIVES: (1) Study the resistance of large slatted antenna to blast, measure slat distortion, evaluate structural loads and determine the effects that the feed system has in deflecting the airblast onto the antenna. (2) Obtain stress loadings, determine resistance to buckling and study the behavior of flanged joints on an integrated mast under blast loading when supporting an antenna. (3) Increase shock hardness of

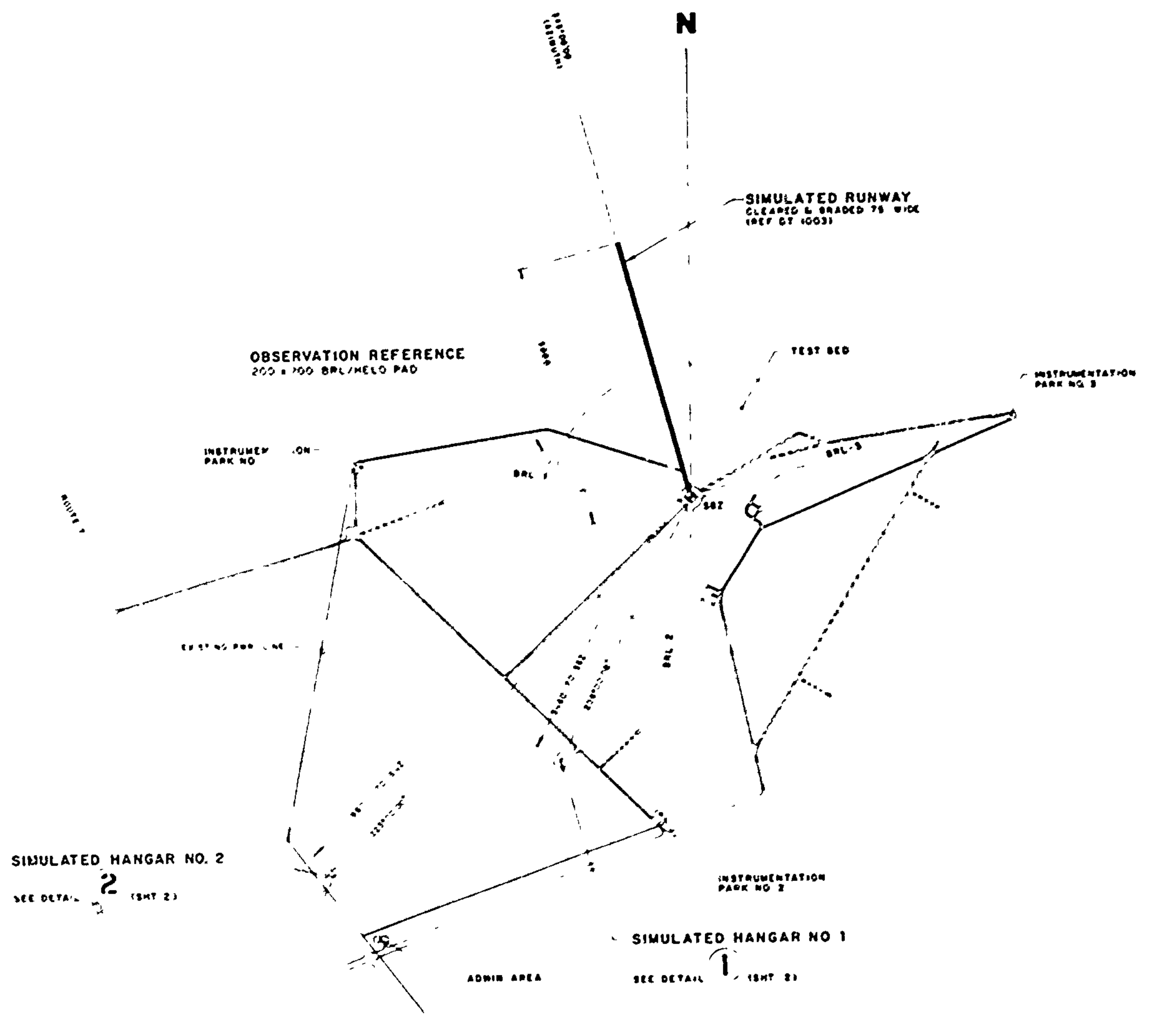
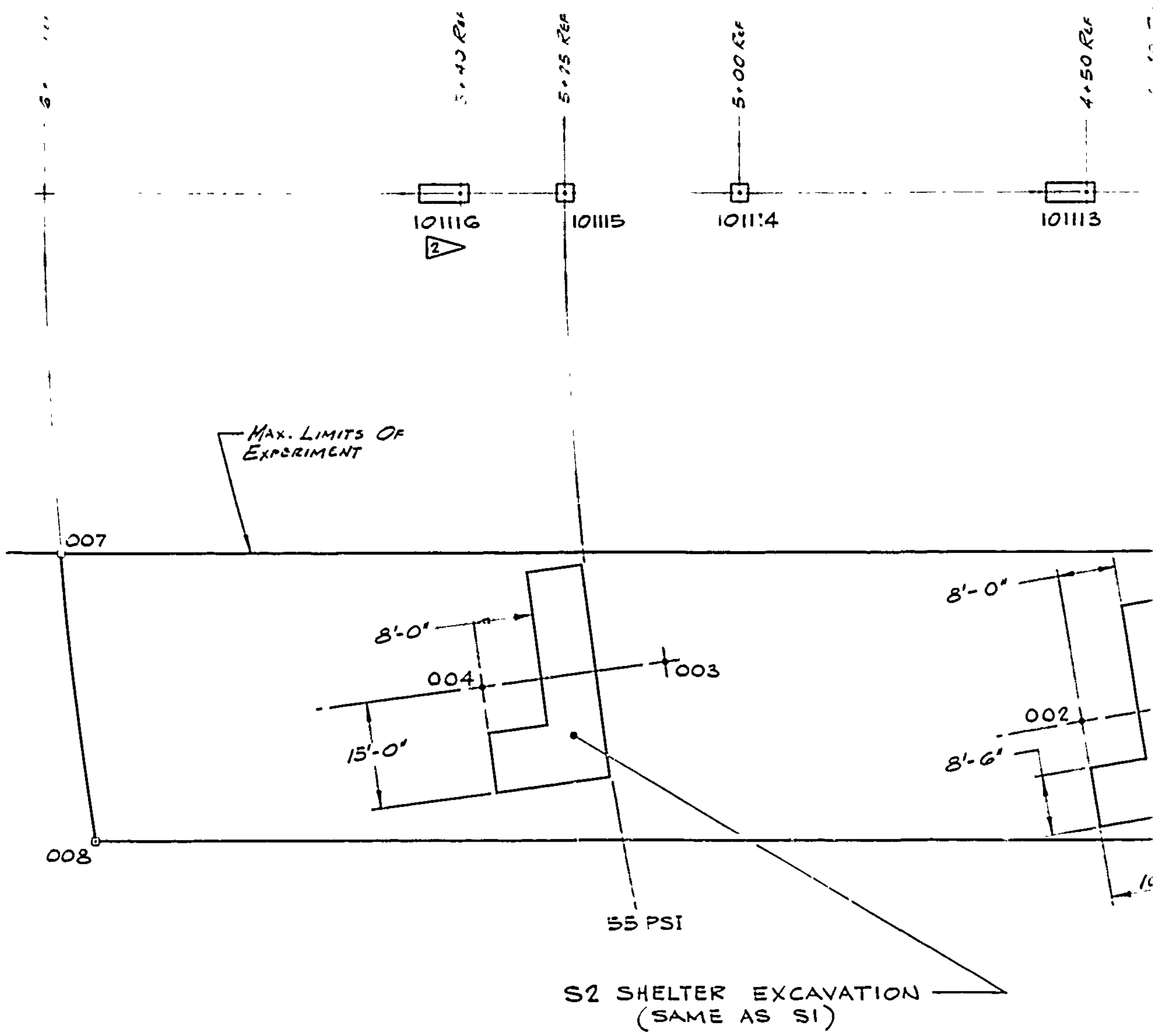


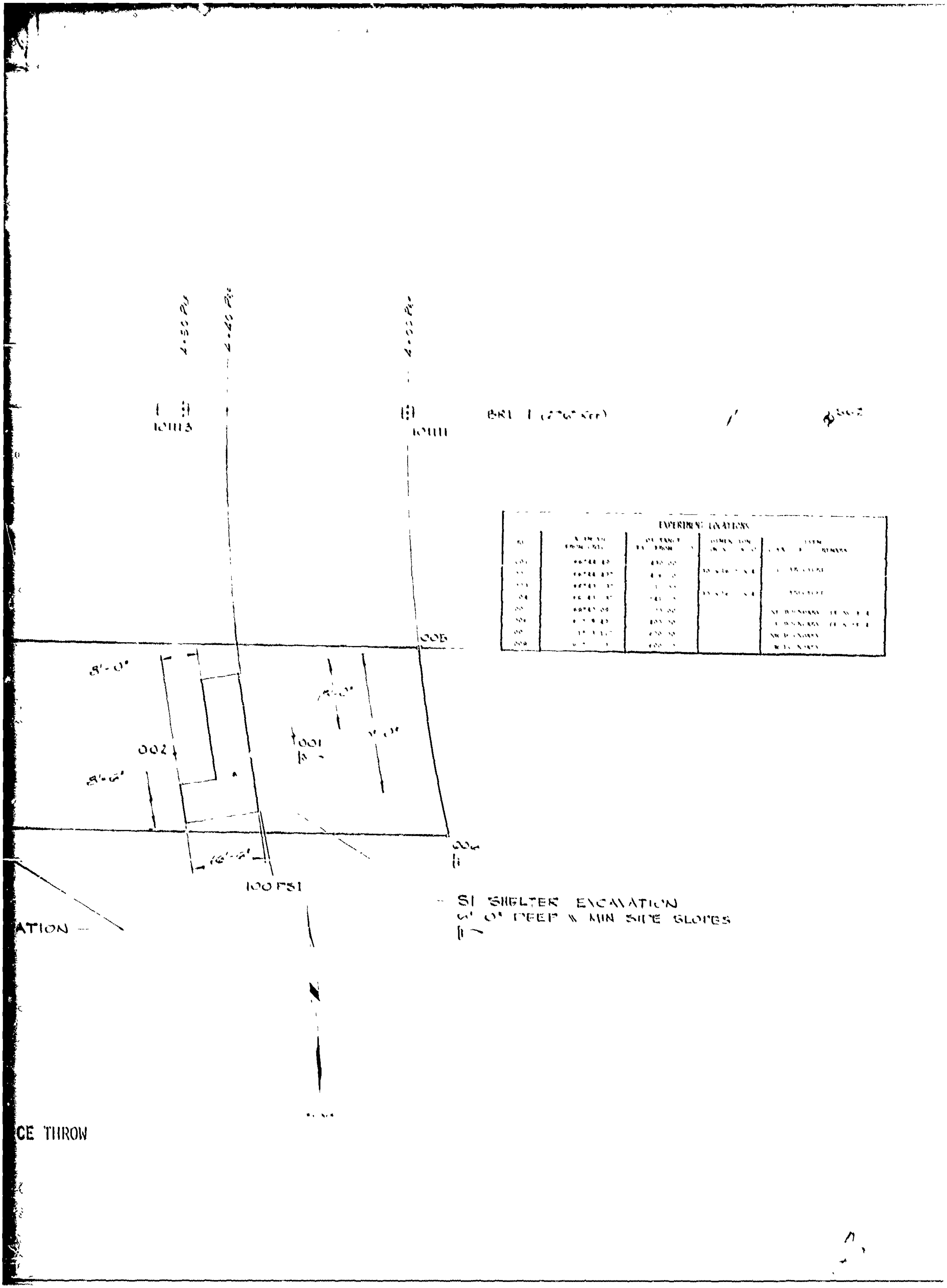
Figure 3-106. SAC Experiment Layout, DICE THROW



NOTES:

1. SEE CERF/SWEDEN JOB SPEC. 622-2050/68, ERECTION PLAN (SHT's 1-11), FOR CONSTRUCTION DETAILS.
2. BRL FREE-FIELD AIR BLAST GAGES ARE SHOWN FOR REFERENCE ONLY SEE FCDNA DRAWING NO. DT-1025 FOR CONSTRUCTION DETAILS.
3. ALL CERF/SWEDEN REFERENCE POINTS (RP's) ARE PREFIXED BY "169": E.G , 169001. LOCATE WITH 1" x 2" x 12" (MIN.) WOODEN STAKES PERMANENTLY MARK RP NUMBERS ON ALL STAKES.
4. BOUNDARY CORNERS ARE LOCATED BY 2" x 2" x 12" (MIN.) WOODEN HUBS WITH RP NUMBERS PERMANENTLY MARKED. RP 169005 IS A MUTUAL REFERENCE POINT WITH 160009 AND RP 169006 is MUTUAL WITH 160008.

Figure 3-107. Sweden/CERF Experiment Layout, DICE THROW



10113
10111
005
002
001
8'-0"
8'-6"
16'-8"
100 PSI
EXPERIMENT LOCATIONS
REMARKS
SI SHELTER EXCAVATION
ATION
CE THROW

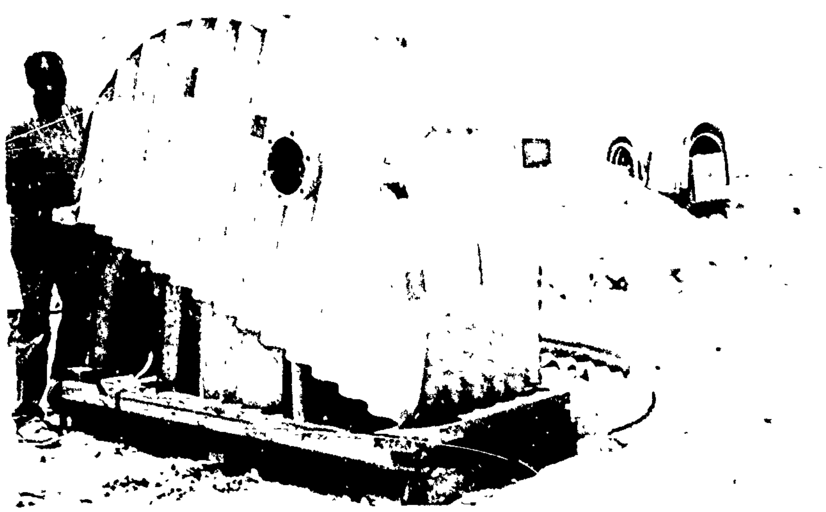


Figure 3-108. Sweden/CERF Personnel Shelter During Construction, DICE THROW

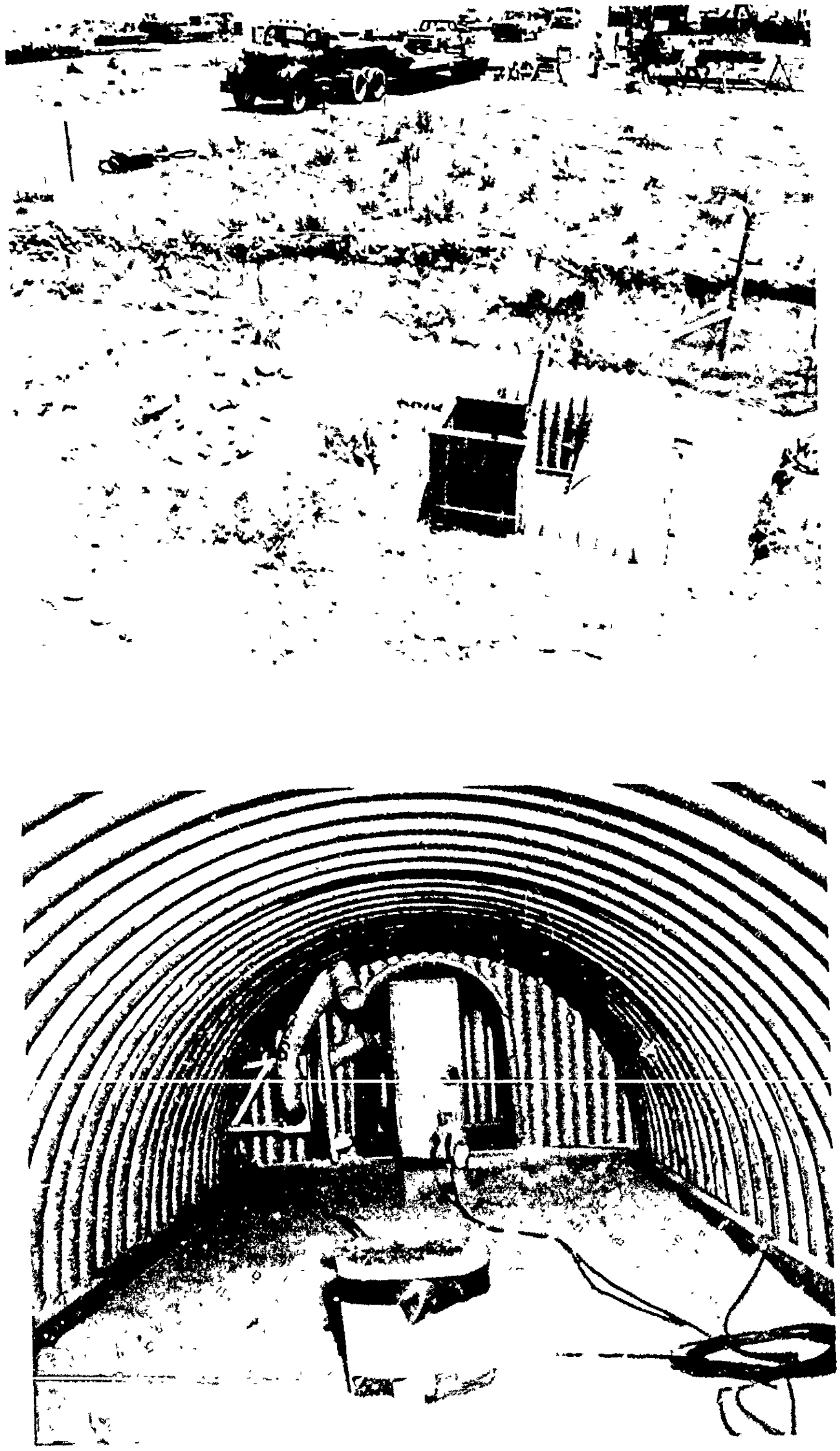


Figure 3-109. Sweden/CERF Personnel Shelter, Exterior and Interior Views, DICE THROW

a vented radome by new method of GRP (glass reinforced plastic lay-up), and (4) Test the blast hardness (fail/not fail) of two whip antennas.

EXPERIMENT DESCRIPTION: (Refer to Figure 3-110 for a detailed experiment layout and Figure 3-111 for an overview) (1) The slatted antenna was placed at the predicted 5-psi (35-kPa) overpressure range on a 26x14x12-ft (7.9x4.3x3.7-m) concrete block base (refer to Figure 3-111). A dummy feed was attached to an open framework at the top of the tubular mast. (2) Two integrated masts, one steel and one aluminum were placed at the expected 10-psi (70-kPa) and 5-psi (35-kPa) overpressure range, respectively. These two structures, consisting of a dummy antenna mounted on a tubular steel mast 12 ft (3.7 m) long, 19-1/2 in. (50 cm) O/D and thickness of 1/2 in. (1.3 cm) were supported on a lower conical steel strength shell 2 ft (0.61 m) in diameter at the top expanding to 3 ft (0.91 m) in diameter at the bottom. The length of the shell was 5 ft (1.5 m) and its thickness was 3/8 in. (0.95 cm). Refer to Figure 3-112. (3) A vented radome with GRP lay up [approximate size 3 ft (0.91 m) in diameter at base and 3 ft (0.91 m) high with a domed top as an integral part of the body] was placed at the expected 10-psi (70-kPa) overpressure range. Venting was by means of openings at the bottom and around the circumference. Inside the radome (also at the bottom) was a deflector skirt which directed the airblast up the inside walls and clear of equipment to be protected. The radome was bolted to base rings set in a concrete raft (refer to Figure 3-112). Two whip antennas were included in the test area to determine blast hardness.

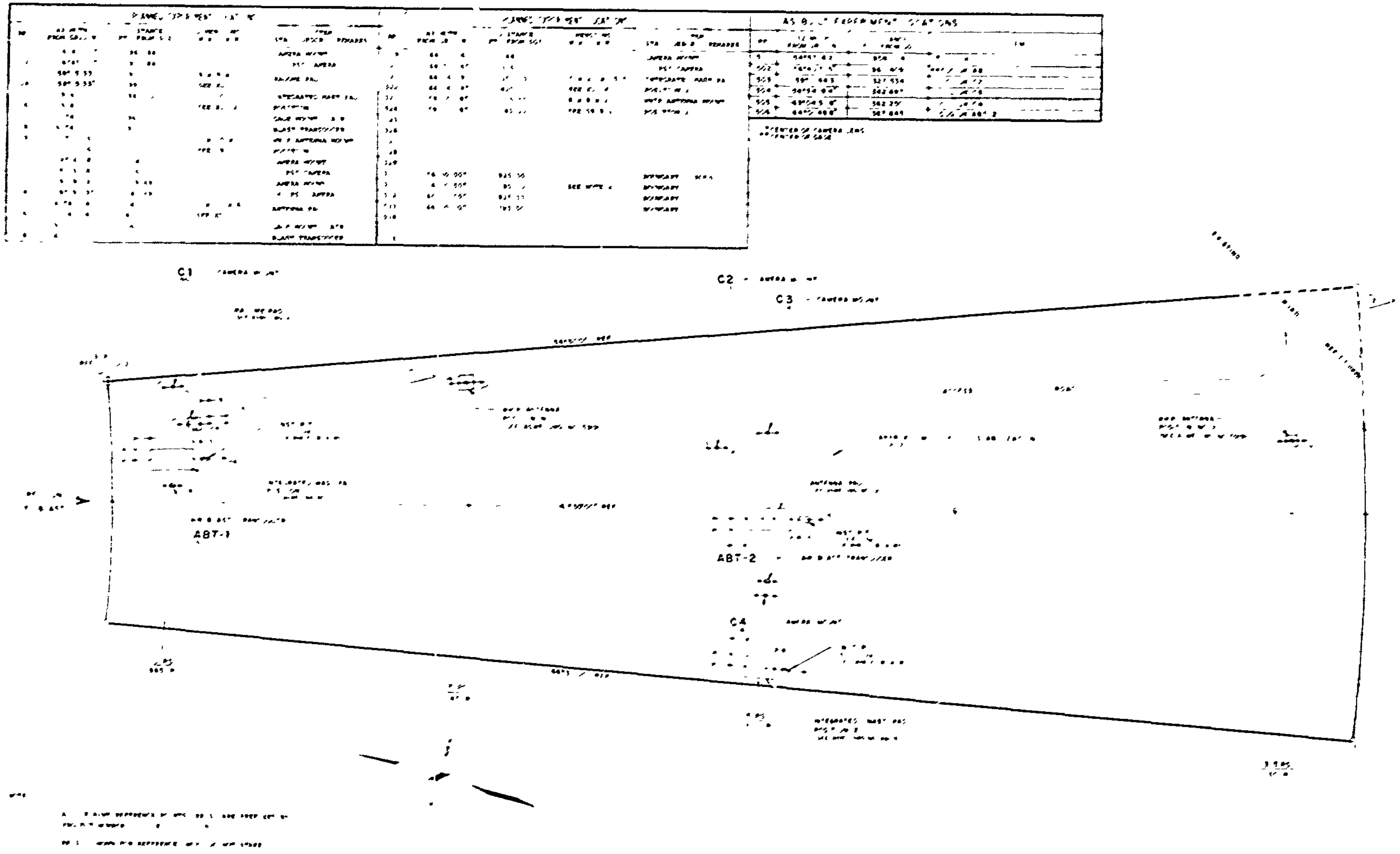
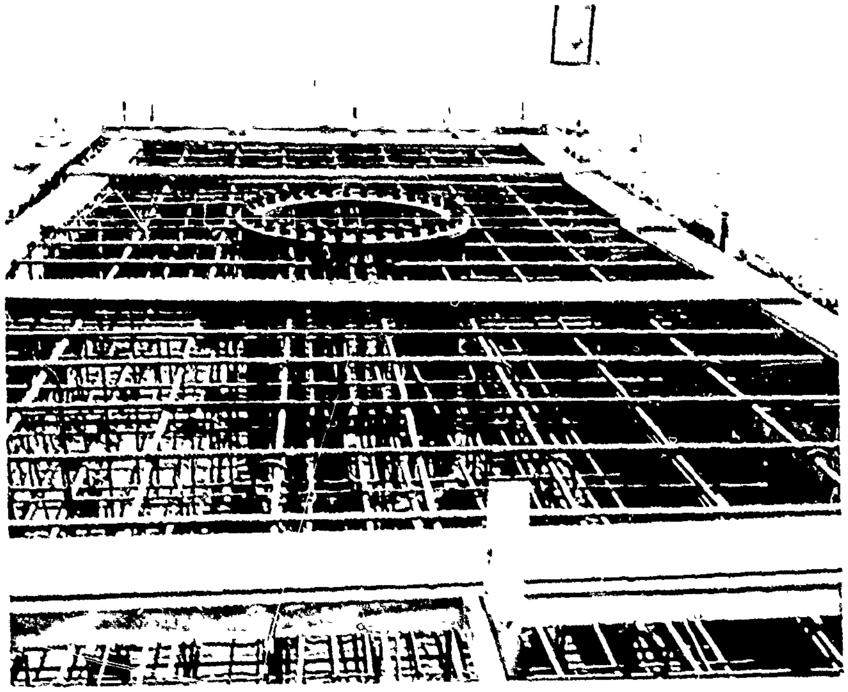


Figure 3-110. UK/ASWE Experiment Layout, DICE THROW



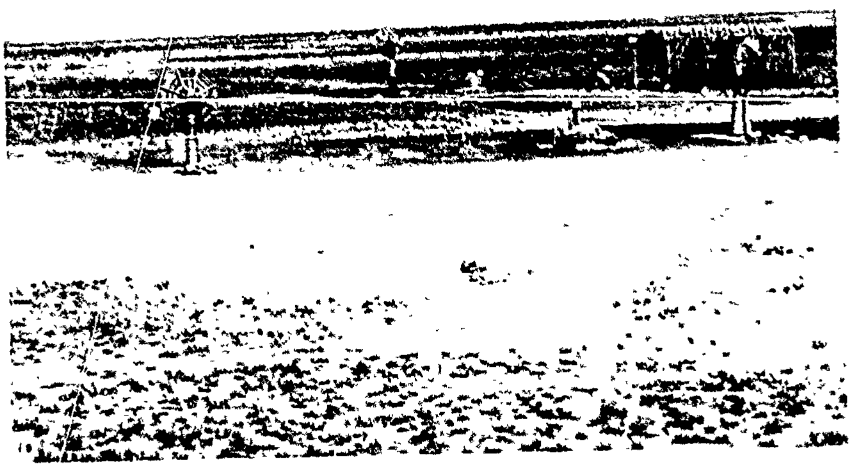


Figure 3-111. UK/ASWE Foundation for Slatted Antenna During Construction (Top Photo), and Overall View (Bottom Photo), DICE THROW

Figure 3-112. UK/ASWE Integrated Mast (Left Photo) and Vented Radome (Right Photo), DICE THROW

27. U. S. Army Engineer Waterways Experiment Station (WES)

(a) TITLE: Mobility Experiments (Post Test), DNA Project #174

PROJECT OFFICER: Mr. A. Rula (601) 636-3111

OBJECTIVES: Determine the degree to which craters formed in a layered natural material by a large surface explosion constitute a physical barrier to the movement of military vehicles (tanks, armored personnel carriers, and cargo carriers).

EXPERIMENT DESCRIPTION: The vehicles used in this experiment were as follows: M60 tank, M551 vehicle, M577A1 Command Post Carrier, M109 self-propelled howitzer, M35A2C 2-1/2-ton cargo truck, and M715 1-1/4-ton cargo truck. These six vehicles were used in a series of mobility experiments to be conducted after the detonation. (Refer to Figures 3-113 and 3-114.)

Self-propelled and speed tests were conducted with the six test vehicles. Also drawbar-pull and motion-resistance tests were conducted with the M577A1, M35A2C, and the M715. All data will be compared with results predicted by using WES analytical modeling techniques. If any craters are impassable, the amount of engineering (dozer) effort required to construct a passable route for vehicles will be determined.

(b) TITLE: Army Personnel Shelters, DNA Project #329.

PROJECT OFFICER: Mr. R. Mlakar (601) 636-3111, ext. 3365

OBJECTIVES: Determine the structural response, interior pressure, and survivability of six structures. Provide data analysis verification.

EXPERIMENT DESCRIPTION: In this experiment there were six shelters tested (refer to Figure 3-75). Two above-ground corrugated-metal fighting bunker covers (APS-2a and 2b), one each located at the 20- and 10-psi (140- and 70-kPa) ranges from ground zero; both of these bunkers were

Figure 3-113. U.S. Army (M551) Armored Reconnaissance Airborne Assault Vehicle During Mobility Test, DICE THROW

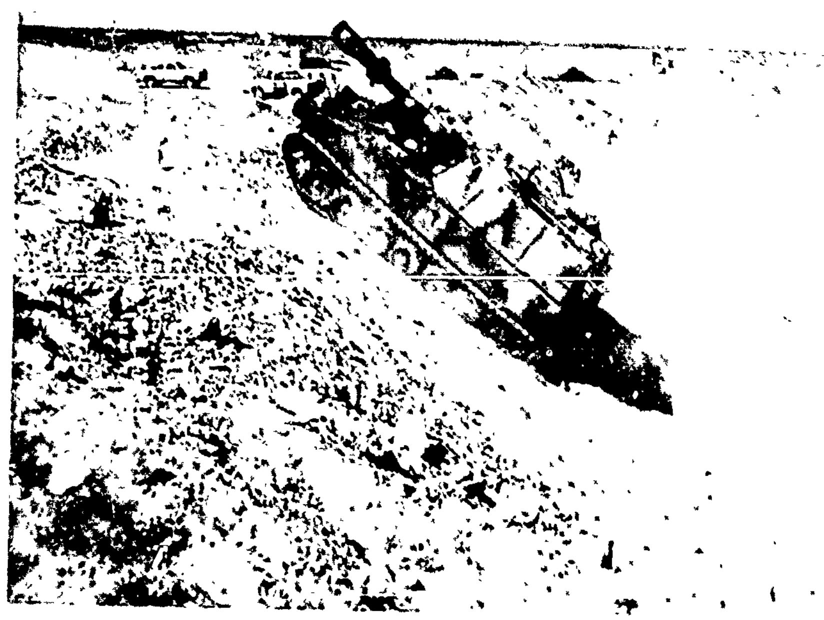


Figure 3-114. U.S. Army (M109) Self-Propelled Howitzer During Mobility Test, DICE THROW

instrumented. Two small, elliptical, metal-framed, fabric-covered, buried personnel shelters (APS-1a and -1b), located at the 30- and 20-psi (210- and 140-kPa) ranges, were instrumented. One large, elliptical, metal-framed, fabric-covered, buried personnel shelter (APS-3) was located at the 30-psi (210-kPa) range. This shelter was instrumented with passive devices only. One rectangular, metal-framed, fabric-covered buried personnel shelter (APS-4) was located at the 30-psi (210-kPa) range. This shelter was also instrumented with passive devices only. There were 41 channels of instrumentation recorded, which consisted of acceleration, velocity, strain, airblast pressure and soil stress.

Follow-on tests are to be conducted on the undamaged structures with fuel-air explosive (FAE) weapons. The objectives of these post-event tests are to gather data and develop criteria for determining the effects of fuel-air munitions on urban structures and field fortifications (refer to Figure 3-115).

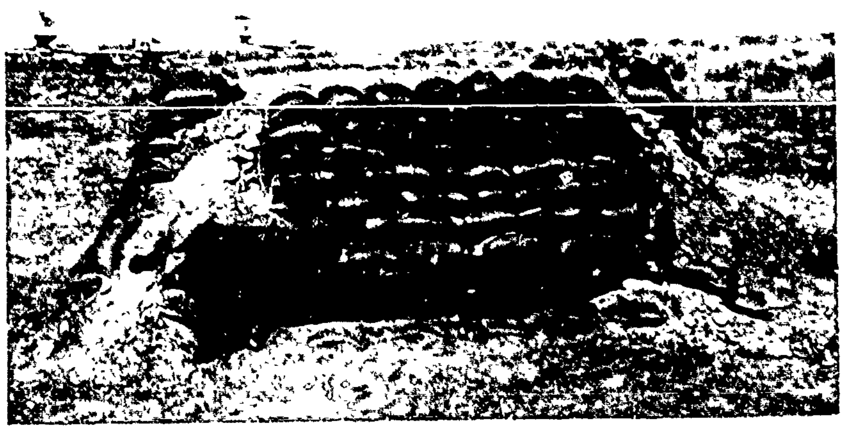


Figure 3-115. WES Army Personnel Shelter, DICE THROW

28. White Sands Missile Range (WSMR)

TITLE: Fielding Support

PROJECT ENGINEER: Mr. R. Dysart (915) 678-5901

UP-RANGE FACILITY ENGINEER: Mr. D. Green (915) 678-4275

SUPPORT AND EXPERIMENT DESCRIPTION: WSMR provided the following support: construction (including a batch plant for mixing of concrete, trucks to transport the mixed concrete, and crushed rock for the construction of roads from a quarry located on WSMR); communications, including installation of the telephone and intercom systems; security and fire protection; survey (Defense Mapping Agency; refer to "Introduction" section of this chapter for reports identifying pre- and post-test surveyed target locations); and meteorological information (weather observation reports to and on shot day, including pressure, temperature, humidity, air density, speed of sound, wind data and the index of refraction, all versus altitude. Refer to "Meteorological Report Ascension" #234, 6 October 1976, Stallion Range Center, Log 0700). WSMR also provided skilled personnel to accomplish the above tasks.

The WSMR experiment consisted of providing the documentary and technical photography for the event. Table 3-16 gives a list of cameras used in this experiment.

29. Williamson Aircraft Company

TITLE: Aerial Photography

PROJECT OFFICER: Mr. R. Williamson (WAC) and Dr. D. Roddy (USGS)

OBJECTIVE: To perform stereographic photography of the DICE THROW EVENT.

EXPERIMENT DESCRIPTION: The photographic aircraft flying at an altitude of 6500 ft (1981.2 m) MSL with a speed of 80-100 knots (148.2-185.2 kph) entered the WSMR from the west and proceeded to the GZ area. It remained over the GZ area, taking stereo pictures of the test-bed area and crater. Pictures were also taken of this blast to detect the existence of anomalies.

Table 3-16. WSMR Camera Details, DICE THROW

Camera Type	Location	Framing Rate (frames/sec)	Lens (mm)	View
Mitchell	Helo Bunker	24	35	Helo pilot & instrument panel
DB Milliken	NWEF Aircraft	400	16	A4D Aircraft
DB Milliken	NWEF Aircraft	400	16	A4D Aircraft
DB Milliken	NWEF Aircraft	400	16	A4D Aircraft
DB Milliken	Sandia Antenna	400	16	50-Foot Antenna
	Rt. 7 and West Access Road	10	70	Cloud Rise
	Rt. 7 and West Access Road	128	16	Cloud Rise

APPENDIX A

1. DICE THROW Test Group Engineer's Report

2. Countdown Procedure for Pre-DICE THROW II, Event 1

3. Pre-DICE THROW and DICE THROW Reference Drawings List

4. Pre-DICE THROW and DICE THROW Reference Documents List

DICE THROW TEST GROUP ENGINEER'S REPORT

by

C. A. Klimmek
LT, CEC, USN

ABSTRACT

This report is a compilation of ideas generated and lessons learned by the Engineering Staff during project DICE THROW. The purpose of this report is twofold: first, to give future Test Group Engineers an idea of the areas of engineering involved in an HE program and of the complexity of this involvement; secondly, to point out specific problem areas encountered during DICE THROW and to provide recommended solutions to these problems.

The report is arranged in three general categories: planning, fielding, and cleanup. Each category has numerous topics. The topics of the planning phase are covered chronologically, whereas in the fielding and cleanup sections the topics are presented in a more random order.

Although every HE test program is unique to its own purpose, location, and set of experiments, there are areas which are common to all. Examples of common areas are power distribution systems or road network layout. It is to these general areas that this report is directed.

APPENDIX A

1. INTRODUCTION

The Test Group Engineer (TGE) is responsible for the planning and development of the test site and for providing construction support to experimenters. On DICE THROW the TGE was aided by the services of Ken O'Brien and Associates (KOA), a consulting engineering firm. One engineer assisted full time through completion of the project, and one senior engineer (electrical) was used, primarily during the planning phase, for development of the power distribution and instrumentation cable layouts.

The controlling elements in the design of the test-site layout are the test-bed layout and the location of the trailer parks. These items are the responsibility of the Technical Director (TD), although the TGE should provide input on cost effectiveness from the construction point of view. After the selection of these items the TGE can begin design of the road network, the power distribution system, and instrumentation cable systems. The latter item is primarily the responsibility of the Cable Coordinator (CC), but must be closely coordinated with the TGE.

The planning of construction support for individual experiments is largely contingent upon input from the experimenters. Obtaining adequate information with sufficient lead time to properly plan the work proved to be a major problem for the TGE on DICE THROW.

Except for the AFWL and the SRI/FRG projects, which were accomplished by civilian contract, all construction on DICE THROW was done by the Up-Range Facilities Engineer (FE) at White Sands Missile Range. To initiate work, the TGE would submit a work request, with appropriate drawings and specifications, to the WSMR liaison at the Army Test and Evaluation Command, who would in turn task the FE to perform the work. In the field, direct communication existed between the TGE and the FE. The working relationship between the TGE and the FE was very good. A major advantage is realized by using a government construction agency working directly with the test staff, in that the staff is free to use phase construction and to adjust the program as it progresses without initiating cumbersome and expensive change orders.

2. PLANNING PHASE

The principal factors affecting the design of the test-bed layout are the requirements of the experimenters. The TD generally has the lead in positioning the various experimenters within the test bed. It is prudent for the TGE, however, to provide input from a construction standpoint. Specific elements to be considered include layout area size and shape, power requirements within the layout, location of free field airblast lines, and access requirements.

The TGE's first detailed information on experimenter requirements comes from the Technical Support Plan (TSP) completed by each experimenter. FCDNA provides a standard format for the TSP, of which construction support is only one of many sections. On DICE THROW, it was found that the format of the TSP construction support section was too general, and considerable variation was encountered in the quality of information received from the experimenters. It is intended that this section of the TSP will be rewritten prior to the next large HE test program.

Another problem area was in the quality of layout and construction detail drawings received from the experimenters. Again, variation was considerable, ranging from "back-of-the-envelope" sketches to standard A-E construction drawings. FCDNA invested much time and effort in redrafting drawings in order to standardize the layouts and make the drawings acceptable for use by the construction agency. This investment of effort was worthwhile in that it allowed a smooth-running, well-planned construction phase; however, in retrospect, it is felt that the burden of providing adequate construction drawings and more standardized layout drawings should have been put on the experimenter. This would free FCDNA to concentrate on coordination of projects and construction management. The responsibility for proper drawings could be put upon the experimenter if the TSP were sufficiently detailed to serve as a directive and guide.

Along with drawings, the experimenter shoul be tasked to provide specifications. The specifications need not be complete construction specifications, unless the work is to be done by contract, but should be sufficiently complete so that the TGE can determine generally what is needed. Specifications included on the drawings as notes served quite satisfactorily for the United Kingdom experiment on DICE THROW. The items most often requiring specification on DICE THROW experiments were those listed in Table 1.

Table A-1. Specification Topics

Concrete	strength required tests finish curing requirements
Reinforcing Steel	strength splices
Backfill	material compaction lift depths
Tolerances	level of concrete pad anchor bolt location
Welding	

A final area where initial experimenter input needs to be improved is that of power requirements. The TSP format used on DICE THROW again was not adequately detailed. It also will be rewritten.

Speaking from experience, the author strongly recommends that the TGE refrain from becoming involved in the design of any experiment unless specifically tasked to do so. Such "volunteer" efforts can snowball into involved and time-consuming jobs.

a. <u>Preparation for Project Officer's Meeting</u>

The Project Officer's Meeting (POM) for DICE THROW was held approximately nine months prior to the test. This meeting afforded the TGE his first opportunity for direct contact with the experimenters. Considerable time and effort went into the preparation of individual layout and construction detail drawings for each experiment prior to this meeting. Because many changes in layout occurred as a result of the discussions at the POM, and because many experimenters did not have their construction details finalized until after the meeting, it is felt that this effort was premature.

After the POM, a large-scale composite layout drawing was developed. This drawing was used extensively through the remainder of the planning phase. It is recommended that on future projects a composite drawing of this nature be developed prior to the POM and used as the primary-planning drawing. This will reduce the drafting effort, and it will also provide a better planning tool. On this single drawing, details of his own experiment layout, as well as of any interactions with neighboring layouts, will be readily apparent to the experimenter.

Drafting of detailed construction drawings should not be done by FCDNA prior to the POM. As mentioned in the previous section, FCDNA's efforts during this period should be aimed toward getting the experimenters to provide quality construction drawings and specifications.

Two additional preliminary drawings that should be available for the POM are the site plan and the test-bed layout (Reference Dwgs. DT 1000 and DT 1001). These drawings can be reduced to notebook size for convenient reference by attendees at the POM.

Several major decisions must be made prior to the POM in order that the intended purpose of the meeting can be accomplished. The following information must be available: Ground Zero location, free-field gage line azimuths, instrumentation trailer park locations, and airblast predictions. Final airblast predictions were not available for the DICE THROW POM. Significant rework of drawings was required when these predictions were completed. In addition, it is highly desirable to have the location of the administration area, the layout of the primary road system, and the source of electrical power determined prior to the POM.

b. Project Officer's Meeting

The POM allows the TGE to present the proposed site and test-bed layouts to the experiment Project Officers. More importantly, each experiment can be discussed in detail with the Project Officer associated with it. The areas of primary concern to the TGE are requirements for construction support, power, signal cable, timing, and surveying support.

During the DICE THROW POM experimenters rotated among staff members to discuss specific topics. Construction support and surveying were covered by the TGE and his assistant, a KOA engineer, cabling by the Cable Coordinator and power distribution by the Electrical Engineer (also of KOA). On DICE THROW, timing was provided by an outside agency, whose representative was in attendance at the POM.

It is felt that improvement in the POM format could be accomplished by separating discussions of experimenters with the TGE from those with the Program Analyst (PA). The interests of the TGE and the PA are not closely related at this point in the project. The TGE is interested in finalizing the experiment layout and obtaining construction details, whereas the PA is primarily interested in costs.

As stated previously, the composite test bed drawing should be the primary planning tool during the POM. The experimenter should be tasked in the TSP to provide construction detail drawings prior to the POM, so that these can be reviewed by the TGE and discussed at the POM.

At the conclusion of the POM, or as the final discussion, the TGE, Cable Coordinator, Electrical Engineer, and Timing Representative should coordinate the layouts of the power, signal, and timing cable systems. Although not scheduled, this was done to some extent at the DICE THROW POM. Sufficient time was not available to hold adequate discussions.

Minutes of each discussion at the DICE THROW POM were not generated. It is recommended that this be done in the future. Emphasis should be placed upon decisions to be made, dates determined for these decisions, other milestone dates decided on, and decisions regarding agency versus DNA responsibilities. It would be a good idea to document, insofar as is possible, all conversations from this time forward, with copies of such documents sent to the agency concerned.

c. Post-POM Planning

After the POM, the TGE has an enormous amount of work to do in a short period of time. The site plan must be finalized and survey support contracted for in order that the surveying of roads, trailer parks, etc. can begin. At the same time, work must begin on a composite cable plan. This drawing should show all signal, power, timing, firing, and communications cabling.

It is recommended that a mylar reproducible copy be made from the updated composite layout drawing to serve as a form for the composite cable drawing. Mylar permits the use of grease pencils to make the numerous changes which occur during the development of this drawing.

Additionally, work should begin on the development of a total power requirement estimate. The information required from the PO's for this estimate includes type of power (AC or DC), location (trailer park, test bed, bunker) of the power outlet, use (camera, instrumentation, construction), and the amount and general time frame of the estimated usage. The total estimate should also include an allowance for add-on experiments and for growth of existing experiments. From this estimate the TGE can decide on what type of power distribution system to use, and then can begin to work on power detail drawings and acquisition of the system.

Work can begin on a few of the experiment layouts after the POM. On DICE THROW, most experimenters were not ready with a final layout specification until they had had time to digest the discussions of the POM. It is recommended, however, that work begin at this time on as many layouts as possible. To avoid repetitious work, the calculation of Reference Points (RPs) should be delayed until the experimenter is sure of his layout. It is essential that finalization of the shock environment layout, in particular, be completed soon after the POM. A close working relationship must exist between the TGE, the TD and the shock environment PO in order to accomplish this.

Construction specifications were written for DICE THROW but were never utilized extensively. Because of the day-to-day working relationship between the TGE and the FL, verbal specifications were possible. If non-government construction forces are used it will be necessary to pay more careful attention to the preparation of written specifications.

d. Second POM

Although a second POM was not held on DICE THROW, such a meeting should have been of considerable benefit to the TGE. The purpose of such a meeting would be to finalize the experiment layout and requirements for construction support for each experiment. This would have provided a cutoff date by which experimenters were required to finalize their support needs. It was found on DICE THROW that, to get these final requirement specifications, the TGE or his assistant had to, in most cases, confront the experimenter in person. The disadvantage of holding a second full scale POM, from the TGE's standpoint, is the limited amount of time that is available with each individual PO.

Ideally, an individual meeting with each experimenter is the most desirable way to finalize layout and construction planning. On several of the more complex DICE THROW projects, the experimenter visited FCDNA to finalize layout and discuss construction support. The advantage of requiring the PO to visit FCDNA is that he will be more likely to have completed preparations for the visit before making the trip at his own agency's expense.

One final point to be emphasized is the importance of finalizing the layouts of those support experiments which impact on layouts of other experiments at the earliest possible date. Experiments in this category include such things as free field airblast measurements, technical photography, timing and firing, and ground motion measurements.

e. Drawings

Comments concerning drawings are made throughout this report. Several additional suggestions are presented here.

Considerable discussion centers around the use of metric versus English systems of units during this period when the United States is undergoing a transition from one to the other. At this point in time, it is still necessary to use the conventional English system for construction work. On DICE THROW English units were used on all FCDNA drawings, although metric scales were provided on general site drawings. Because many agencies are required to work in the metric system, it is recommended that consideration be given to the use of a "ratio" scale on layout drawings. Such a scale would enable a user to utilize any measurement system and still scale the drawings directly.

Other recommended drawing improvements include: use of a larger scale on trailer park layout drawings; use of ink only for site, test-bed, and survey monument layouts — other drawings should be maintained in pencil until it is reasonably certain that further changes will not be made; showing of all gage line cable runs from GZ to 1500 feet (J-Box location) on one drawing and all of those from 1500 feet to the trailer parks on a second drawing; and finally, incorporation of cable pull sheets as part of the cabling series drawings.

3. FIELDING PHASE

a. Engineering Staff

In the field, the TGE was concerned with overall coordination and scheduling, construction inspection, and field design changes. The assistant TGE (KOA), or ATGE, did not report to the field full-time until site preparation was complete and construction effort had shifted to support of experiments. The primary concerns of the ATGE were with surveying support, project layouts, maintenance of construction drawings, and field design changes.

Although the Cable Coordinator (CC) was not under the TGE in the DICE THROW staff organization, he did work directly with the TGE and receive coordination and scheduling guidance from him. Because of the complex interaction of construction and installation of cables, a close working relationship between the CC and the TGE is essential. For that reason the CC is considered a member of the engineering staff.

The responsibility for installation of the power distribution system on DICE THROW was that of the CC. It is recommended that, if the designer of the power system is available (as he was during DICE THROW), he be tasked with supervising the installation and troubleshooting of the power system. This is a critical aspect of fielding an HE test, as is cable installation, and separate, full-time supervision for these two functions is recommended.

Because of the relatively close proximity of the DICE THROW test site to FCDNA Headquarters, the need for on-site drafting and drawing reproduction never became critical. In retrospect, it is felt that these capabilities should exist in the field. They become even more necessary as the test site becomes more remote.

Another capability which would have been very useful to the DICE THROW engineering staff was that of elementary surveying. The availability of modern survey equipment would have enabled the staff to perform short-notice survey work themselves and also to check the work of the construction survey crew. The latter was found to be necessary because of the criticality of knowing experiment locations precisely relative to ground zero.

It is important to adhere to established lines of communication during the construction phase. On DICE THROW, the TGE staff was the liaison between experimenters and the construction forces. The FE took direction only from the TGE. This was necessary because of the large number of projects under construction simultaneously. It was the TGE's responsibility to set priorities and to schedule the construction.

Informal TGE staff meetings were held every afternoon. They served primarily as an opportunity for exchange of information between the construction people and the TGE. It would have been of benefit to the entire project if regular test group staff meetings had been held as well.

b Surveying

The Defense Mapping Agency (DMA), a tenant command on WSMR, provided the surveying support for all DICE THROW events. Because of DMA's high cost and less than adequate service in the areas of on-call response time and receipt-of-data time on Pre-DICE THROW, FCDNA looked into the possibility of using civilian survey support, including aerial photography, for the main event. Circumstances, however, required the use of DMA. A TGE Memorandum for Record, dated 5 January 1977, summarizes and evaluates the support received from DMA on the DICE THROW main event. In general, this support was satisfactory and a significant improvement over that provided for Pre-DICE THROW.

The number of permanent control points on DICE THROW could have been reduced significantly. It is recommended that, for future tests, rather than establishing all control points during the initial stages of fielding, the agency or firm providing survey support be consulted to help determine the number of control points required to meet the needs of the experiments. As fielding progresses, additional control points can be added as necessary.

It was found on DICE THROW that the control point at surface ground zero (SGZ) was used for about 98 percent of the layout work. The other control points were used during as-built and post-shot surveys.

The reference point (RP) system developed for DICE THROW was quite satisfactory (Reference Dwg. DT 1002). The use of rebar posts as permanent RP's for those experiments where gross movement measurements were desired greatly reduced the as-built and post-shot surveying requirements. In those cases, experimenters were able to measure from the closest RP to any point on the experiment with a steel tape.

Two additional minor lessons were learned concerning surveying support. These are, first, that the placement of a control point on an existing mound greatly reduces problems of obstruction and heat distortion, and, second, that construction crews prefer to have corners rather than centerlines staked for excavations.

c. Scheduling

On a test group staff, the Program Analyst (PA) is responsible for development of the test schedule. This schedule is not usually a detailed construction schedule. If a construction schedule is needed, the TGE generally should develop it. It is important, however, for the TGE to work closely with the PA on all scheduling activities.

For DICE THROW, the TGE investigated the use of computer scheduling techniques. The necessary computer capability is available at FCDNA. The only program currently available, however, is the IBM Project Management System, 360A-CP-04X, Version 2. This program would adapt well to long range planning and cost tracking for an HE program. It is not suitable, however, for detailed construction scheduling over the short range, and hence was not used on DICE THROW. It is recommended that this subject be investigated again for future tests.

On DICE THROW, project changes and add-ons were permitted almost until shot day. Although this policy put considerable strain on the construction effort, in most cases the requested changes and additions were completed. That this was possible was due primarily to the fact that a government construction force was being used, and formal change order procedures were not necessary. It is strongly recommended that the TGE for future tests establish realistic cut-off dates for add-ons and major project changes. This is particularly necessary if construction is to be accomplished by civilian contractors.

d. Roads and Drainage

The Class A road network (Reference Dwg. DT 1003) is the first major design item to be completed after the gage lines and trailer parks have been located. Several suggestions are offered based on experience gained on DICE THROW. If at all possible, a 360-degree perimeter road should be constructed. From this there should be two primary access roads to the GZ area. Two are necessary because, during charge stacking, one road must be reserved for explosive access. The use of Class C roads for construction and experimenter access to individual experiment areas was satisfactory. These roads were added as required.

Concerning design of the roads, it was found that a 4-inch base course is an adequate wearing surface for the duration of a fielding effort of the magnitude of that for DICE THROW. The road widths used on DICE THROW, 16-foot minimum for Class A, were marginally adequate. If cost permits, wider roads should be considered. The TGE should take into account the density of traffic and the size of the vehicles which will use the roads. A large amount of oversize construction equipment was needed for DICE THROW.

Drainage was not a problem on DICE THROW. The natural terrain provided slow, wide-spread, unchanneled runoff. Nonetheless, the TGE must consider drainage problems at various locations, such as in trailer parks, cable trenches, buried bunkers, J-Boxes and buried experiments. By obtaining elevation profiles along the gage lines at the DICE THROW site, the TGE was able to determine general flow patterns over the entire test bed.

e. Cabling and Power

The installation of cable is the responsibility of the Cable Coordinator (CC). Cabling to be considered includes signal cable, power cable, timing and firing cable, and communications cable. On DICE THROW, communications cable installation was not under the direct control of the CC, and problems of interference of this system with other cable systems were encountered.

Cable numbers should be assigned to every cable. These numbers should be shown on the composite cable plan as well as tabulated on the "pull-sheet" drawings. All types of cables, including communications cables, should be shown on the composite plan. For ease of handling in the field, the composite drawing can be divided into smaller drawings covering each gage line or each individual experiment.

On DICE THROW, cables laid within 1500 feet of GZ were placed in a 6-inch-wide slit trench and covered. Within 200 feet of GZ, the depth of the slit trench was 4 feet. Between 200 feet and 1500 feet, the depth was 2 feet.

The availability of trenching machines has been a problem in the past. On DICE THROW the FE provided two trenchers, and FCDNA borrowed one each from AFWL and ERDA. Because of heavy use two out of the four machines were normally down for maintenance or repair. It is recommended that consideration be given by FCDNA to the purchase of a trencher for future tests in order to eliminate the need to borrow these machines. There is no guarantee that the machines will be available from other sources next time they are needed.

The practice of using staked RP's at intersections of cable runs was satisfactory (Reference Dwg. DT 1005). Cable numbers were marked on the stakes for the benefit of the cable-laying crew. Yellow ribbon was used on cable RP stakes to differentiate these from experiment RP stakes, which were marked with red ribbon.

Beyond 1500 feet from GZ, cables were laid in a shallow V trench. One pass with a road grader could be used to cut an 8- to 12-inch trench in most instances. The purpose of the trench was primarily that of protection of cables from vehicular traffic. In remote areas of the test bed warning signs and fences were also used (Reference Dwg DT 1005, Sheet 1). V trenches along gage lines were separated from each other to allow the cable-laying rig to pass between them. Power cables were frequently laid on the berm beside the trench rather than in the bottom of the trench to protect them from standing water. Fences and warning signs were used on all power cable runs.

The new cable crossing design (Reference Dwg. DT 1005, Sheet 1, Detail 4) used for DICE THROW proved to be satisfactory and cost-effective. Cables were recovered with minimum damage. The half-culvert design (Reference Dwg. DT 1005, Sheet 1, Detail 3) was used whenever it was necessary to install a crossing over an existing V trench.

On DICE THROW, commercial power was determined to be the most economical and, consequently, was used wherever possible. Two instrumentation parks, the administrative area, three camera sites, and three test bed experiments used commercial power. Only Instrumentation Park 3, one remote camera location and the Canadian experiment used generator power. The Canadian experiment required a generator only because of the breakdown of the 5000-volt cable running from Instrumentation Park 2 to the Canadian bunker. This cable has since been inspected, tested, and marked for 600-volt use only. The damaged section has been removed.

It is probable that a more remote site may be selected for a future HE test, requiring a complete reliance on generators for power. The need for high-quality, full-time generator maintenance and repair services would be paramount in this case.

Difficulty was experienced in estimating the fusing required for some motor generators (MG). Apparently, some of the older units have developed internal friction which has increased the start-up current. It was found that 100-amp fuses were required in many cases despite the fact that operating currents were much lower.

Obtaining accurate power requirement estimates proved to be a difficult task. The problem was primarily one of predicting instrumentation van requirements. This information should be provided to the TGE by the Instrumentation Engineer (IE).

Transformer substations were used to reduce the cable sizes required for transmission of power over long distances to the test bed. The bunker design for protection of the close-in substations from air blast was satisfactory (Reference Dwg. DT 1004, Sheet 6). The only recommended change is that the tops of the bunkers be more securely fixed to the structure. On two of the three bunkers used on DICE THROW, sections of the top grate were jarred loose. No damage to the substations resulted.

f. Logistic Support

With the availability of various support agencies at WSMR, logistic support was not as involved as it might be at a more isolated site. It was found that a central contact person on the test group staff is necessary to coordinate all purchase orders, open purchases, shipment receipts, etc. The TGE attempted to fill that position on DICE THROW; however, because he was in the field at an earlier date than the rest of the staff, he was unable to keep track of logistic matters arranged in Albuquerque. It is recommended that, on future tests, consideration be given to the assignment of responsibility for all aspects of logistic support to a single test group staff member. Alternately, a member of the Logistics Directorate, FCDNA, could be assigned to the staff to fulfill this function.

Open purchase agreements were essential on DICE THROW. Such agreements were held with a lumber company, a hardware store, and an auto parts dealer. An open purchase agreement with an electrical supplier would have been useful; however, none were available closer than Albuquerque. Consequently, the FCDNA procurement office handled each purchase of electrical materials individually. As it turned out, there were more electrical purchases than purchases of any other kind.

Table 2 lists a number of items used frequently on an HE test by the TGE or the CC. It would be prudent to purchase quantities of these items in advance for future tests.

Table A-2. Frequently Used Materials

Item	Quantity Used on DICE THROW
Plastic electrical tape	300 rolls
Rubber insulating tape	200 rolls
Yellow pressure-sensitive tape (NTS)	4 cases
Surveyor's flagging	36 rolls
Sandbags	5000
Copper ground rods	20
Wooden stakes	200
Guy wire anchors	40
24-ply string	3 cones

g. Instrumentation Parks

There are several improvements that can be made in future layouts of instrumentation parks. First, as mentioned previously, it is recommended that larger-scale drawings of the trailer parks be made (Reference Dwg. DT 1006). There is a large amount of electrical equipment and cabling that must be located in the parks. A larger-scale drawing would be helpful in providing clarity of the interaction of items on the drawing.

The spacing between trailers was adequate; however, it is recommended that the instrumentation trailers be turned around on future tests so that the towing end is away from GZ. This will eliminate the crossing of power cables with timing-and-firing and signal cables. Trailers were not oriented this way on DICE THROW because of concern about possible damage to the weaker rear ends of the trailers. This fear could be eliminated through use of a protection device designed for and tested on DICE THROW (Reference Dwg. DT 1008).

An item which seems to be a problem on every test is vehicle-access control in the trailer parks. On DICE THROW, control was attempted through the use of concrete parking bumpers and field wire fences. These proved to be inadequate. Experimenters, apparently unaware of the purpose for which these items were intended, moved the bumpers and cut the fences. It is important to limit traffic among the trailers because of the large number of signal and power cables in that area. A recommended solution is not available at this time; however, consideration should be given to this problem in the future.

All instrumentation trailers and mechanical systems should be thoroughly inspected and tested before they are accepted for use at the test site. Inoperable equipment caused some problems on DICE THROW. The responsibility for this inspection should rest with the IE.

h. Grounding System

The grounding system in each instrumentation park is critical to the overall success of the data collection, and due consideration should be given to it. Many alternate methods were tried on DICE THROW. In the end, it was found necessary to sink copper-pipe wells into the water table. This is the recommended solution where it is practical. In any event, investigation and measurement of ground resistance should be undertaken as soon as the trailer park locations have been selected.

A "ground buss" distribution system was used in the DICE THROW trailer parks. It is believed a "spider" system would have worked more efficiently, and it should be considered for future tests.

Consideration must also be given to a lightning arrester system for each trailer park. The ground for the lightning arrester should be separate from the trailer grounding system.

i. Construction Equipment

On DICE THROW, the WSMR Facilities Engineer (FE) provided most of the construction equipment required. Two concrete transit mixers, a backhoe, and several small compactors were required and were leased by the WSMR-FE.

The type of construction support required by experimenters will naturally determine the equipment needed. Also, it can be assumed that, if work is accomplished under contract, the contractor will provide the equipment necessary to do his work. There are, however, certain pieces of equipment which will be found to be necessary on any large-scale HE event for performance of support functions. A basic list of this equipment is given in Table 3. This equipment, and qualified operators for it, must be obtained one way or another before any large HE event can be fielded. It is recommended that FCDNA consider the purchase of two of these pieces of equipment, a slit-trencher and a reel-o-matic, as an alternative to leasing them for future tests.

j. Field Changes

Last-minute change requests by experimenters can cause significant problems for the TGE and his staff. Although it is understood that the experimenter is motivated by a desire to obtain the maximum amount of useful information from his project, planning and scheduling requirements make it essential that this last-minute activity be kept to a minimum. As mentioned previously, it would be useful for future tests to have a cutoff date established after which neither add-on experiment requests nor major changes or additions to existing experiments could be considered. The add-on and change cutoff dates would not necessarily have to be the same, but it would simplify things if they were. To be successful, this policy would need to have full support and enforcement by the Test Group Director.

On DICE THROW, field design changes by experimenters were processed in an informal manner by the TGE. A written request and full written description of the proposed changes were not required. In the same informal manner these changes were passed on to the FE for action. Sketches or drawings were prepared by the TGE staff to aid the FE, if necessary.

Table A-3. Support Equipment

Item	Use	Comments
1. 4-Wheel Drive Pick-Up (LWB)	For initial site exploration and surveys; to lay small conductor cable	
2. Forklift (RT)	For material off-loading	Crane was used instead of forklift on DICE THROW. Forklift would have been more efficient.
3. Mobile Crane	To load cable on laying trailer; to place air gages and for other heavy material handling	For both support and experimental construction, two 15-ton hydraulic cranes were needed on DICE THROW.
4. Trencher	To cut cable trenches	During critical period, two trenchers were required full time on DICE THROW.
5. Cable-Laying Tractor and Trailer Rig	To lay cable	Trailer is owned by DNA; a 2-1/2-ton or larger tractor is required.
6. Reel-O-Matic	To recover cable	Was leased from ERDA on DICE THROW; can be pulled by tractor of Item 5.
7. Grader	To cut V trenches; to grade gage lines	Could be contracted out.
8. Backhoe	To excavate for air-blast gage mounts and miscellaneous uses	Could be contracted out.
9. Drill Rig	To auger holes for camera mounts and other uses	Could be contracted out.

This system worked satisfactorily, although effort by the TGE would have been reduced under a more formal written request system. A formal "change order" procedure was considered by the TGE but never was implemented.

k. Dust Abatement

A soil-stabilizing agent, trade-named COHEREX and produced by Witco Chemical Company, was used for dust abatement in the vicinity of experiments using exterior photography. The agent was diluted with water in proportions one part COHEREX to four parts water and applied at an average coverage of 0.7 gallon per square yard. A total of 43,000 square yards was covered. COHEREX is a water emulsion of petroleum resins and can be spread with any conventional equipment used for spreading water or asphalt oils. On DICE THROW, the FE used oil distributers to spread the material.

The effectiveness of the dust-abatement effort has not been fully evaluated at this time. It is expected that Denver Research Institute (DRI), who was the prime photographic agency on DICE THROW, will address this item in the report of results. It is known that adequate consideration was not given to negative-phase dust abatement (that is, abatement of dust from behind the subjects being photographed). Also, in the case of vehicles, the area directly underneath each vehicle was not stabilized, and this resulted in interference with photographic coverage because of dust.

4. CLEANUP AND RESTORATION

There are three aspects of test-site cleanup and restoration. First is the recovery of experiments and cable. The Cable Coordinator (CC) is responsible for the latter, which cannot begin until experimenters have released their cable. This normally occurs several days after the shot. On DICE THROW, 393,900 feet of signal cable and 74,200 feet of power cable were recovered.

The extent of construction support necessary for experiment recovery varies considerably with the experiments. It is a good idea to require input from experimenters as to required recovery operations well in advance so that priorities can be established. The most crucial period for recovery operations, and the time that requires the most careful planning in this regard, is that immediately after the shot, including shot day and the day following.

The second aspect of cleanup and restoration is the return of instrumentation vans and power distribution equipment to the Nevada Test Site. On DICE THROW, equipment to be returned to NTS amounted to nine vans and approximately ten flatbed-trailer loads of equipment. Again, this operation can begin as soon as the experimenters have released their vans and equipment.

The final aspect is the actual cleanup at the site of miscellaneous trash and materials and the filling in of the crater. The extent to which the site must be restored will vary from test to test, depending upon environmental requirements of the location and the land ownership. Reseeding and replanting to restore the natural vegetation can be undertaken if necessary.

All cleanup and recovery work on DICE THROW was accomplished by the WSMR FE, under direction by the TGE.

STANDING OPERATING PROCEDURE FOR COUNTDOWN FOR

PRE-DICE THROW II, 100-TON TNT EVENT

I. SCOPE:

This Countdown delineates the procedures to be followed in preparation for the Detonation Test.

II. OBJECTIVE:

To assure that all test operations are performed safely, efficiently, and without error in accordance with approved procedures.

III. ABBREVIATIONS:

SEPO	- Seismic Experiment Project Officer
ATC	- ARMTE Test Conductor
TGD	- Test Group Director
DRI	- Denver Research Institute
TFC	- Timing and Firing Chief, WES
TGE	- Test Group Engineer
OP	- Observation Point
NR	- National Range
RT	- Range Net Talker
PT	- Project Net Talker
SF	- WSMR Safety Representative
ATD	- AFWL Test Director
FT	- FM Radio Talker
CT	- Project Radio Talker
PC	- Program Coordinator
TD	- Technical Director
RB1/2	- Roadblock one/two
SAC	- SAC Project Officer
LPO	- Laser Project Officer
MET	- Meteorological Station, SW-70
MC	- Mission Control
SLA	- Sandia Lab Airblast Prediction Officer
AP	- Arming Party

Pre-DICE THROW COUNTDOWN

(100-Ton TNT Event)

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL TC	INITIAL TGD
T-300	TGD	PT	1. Open Project Intercom Net.	1____		
	TGD	CT	2. Open Project Radio Net.	2____		
	TGD	PC	3. Confirm GZ is clear of all personnel.	3____		
	TGD	PC	4. Confirm all internal roadblocks and barricades are in effect.	4____		
	TGD	RB1	5. Confirm manning of Instrumentation Vans in Instrumentation Park.	5____		
		TGD	6. Receive Final Weather Forecast.	6____		
	TGD	TD	7. Experimenters proceed to GZ area to prepare for test execution.	7____		
	TGD	FT/PT CT	8. Confirm communications with all event manned stations on net.	8____		
	TGD	ATC	9. Request permission to proceed with countdown.	9____		
T-210	TGD	TD	10. Begin VIP tour of Test Bed.	10____		
T-180	TGD	SAC	11. Confirm SAC radar beacons are ready for test.	11____		
T-150	TGD	TD	12. End VIP tour of Test Bed.	12____		
T-125	TGD	PT	13. Confirm DRI personnel are inside bunker.	13____		
	TGD	PT	14. Confirm NR personnel are inside NR van.	14____		
	TGD	PT	15. Confirm SRI laser project personnel are inside Laser Van.	15____		
	TGD	PT	16. Confirm NR personnel are clear of remote stations.	16____		

Pre-DICE THROW COUNTDOWN
(100-Ton TNT Event)

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL TC	INITIAL TGD
T-120	TGD	SF/TD	17. Confirm GZ is clear of all personnel.	17____		
	TGD	RB1/ RB2	18. Firm internal roadblocks (no entry without TGD specific approval).	18____		
	LPO	TGD	19. Request permission to fire laser for next 30 minutes.	19____		
	TGD	RB1	20. Confirm all vehicles except arming party's vehicle are clear of the Instrumentation Park.	20____		
	ATC	RT	21. Open range net if possible.	21____		
		MET	22. First weather balloon release at SW-70.	22____		
T-100	TGD	NP	23. Confirm documentary photographers are on station.	23____		
T-90	TGD	LPO	24. Direct turn OFF of laser.	24____		
		LPO	25. Confirm turn OFF of laser.	25____		
	TGD	MC	26. Verify C-47 on station.	26____		
	TGD	MC/SAC	27. Clear entry of C-47 and B-52's for pre-test flights into GZ area.	27____		
		SLA	28. Furnish initial airblast prediction to Test Control.	28____		
T-75	TGD	SAC/MC	29. Verify SAC #1 B-52 at IP.	29____		
	TGD	AP	30. Direct arming party to enter GZ area.	30____		
T-63	TGD	SAC/MC	31. Verify SAC #2 B-52 at IP.	31____		
T-60	TGD	SAC/MC	32. Verify both B-52's are clear of GZ area.	32____		

Pre-DICE THROW COUNTDOWN
(100-Ton TNT Event)

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL	
					TC	TGD
	TGD	AP	33. Request permission to prepare for arming of charge.	33____		
T-60	ATC	PT/CT/FT	34. Start local countdown at 5-minute intervals.	34____		
	TGD	CT/PT/FT	35. Verify GO condition of all manned stations.	35____		
		MET	36. Second weather balloon released at SW-70.	36____		
T-45	ATC	NR	37. Commence helo sweep of test area.	37____		
	ATC	NR	38. Confirm radar avoidance and area helicopter sweep is complete.	38____		
T-35	TGD	TFC	39. Confirm firing circuit is SAFE.	39____		
	TGD	AP	40. Request permission to arm the charge.	40____		
T-30	ATC	RT/CT/ PT/FT	41. Pickup countdown W/NR (countdown at 5-minute intervals).	41____		
	ATC	NR	42. Confirm external roadblocks are established. Permission granted to arm charge.	42____		
	TGD	MC	43. Verify C-47 is clear of GZ area.	43____		
	TGD	MC	44. Verify CESSNA is on station.	44____		
T-20		AP	45. Report arming of charge complete.	45____		
T-15		AP	46. All members of arming party report final position after clearing of GZ area.	46____		
		SLA	47. Furnish second airblast prediction to Test Control.	47____		

Pre-DICE THROW COUNTDOWN
(100-Ton TNT Event)

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL TC	INITIAL TGD
	TGD	RT/CT/ PT/FT	48. Verify GO condition of all manned stations.	48____		
	TGD	SEPO	49. Request permission to charge GZ Seismic Station.	49____		
T-10	ATC	CT/PT	50. Confirm area clear from D-7.	50____		
	TFC	TGD/ATC	51. Request permission to ready firing panel.	51____		
	TGD	LPO	52. Request permission to fire laser.	52____		
	ATC	NR	53. Lift radar avoidance.	53____		
	ATC	FT/CT/ RT/PT	54. Countdown at 1-minute intervals until T-60 seconds.	54____		
1	ATC	NR	55. Furnish time hack to NR.	55____		
T-5	TGD	TFC	56. Hold if test criteria cannot be met.	56____		
T-5 to -3	ATC	NR	57. Confirm range GREEN.	57____		
T-5 to -3	TGD	TFC	58. Firing panel ready.	58____		
T-60 sec	ATC	FT/CT RT/PT	59. Countdown at 5-second intervals to T-20 seconds.	59____		
	TGD	TFC	60. High Voltage confirm.	60____		
T-20 sec	ATC	FT/CT RT/PT	61. Countdown at 1-second intervals to T-0.	61____		
T-0	TGD	TFC	62. Detonate charge.	62____		
T+30 sec	TGD	TFC	63. SAFE firing system.	63____		

Pre-DICE THROW COUNTDOWN
(100-Ton TNT Event)

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL TC	INITIAL TGD
	TGD	FT/CT RT/PT	64. Confirm personnel status at all manned stations.	64____		
T+5	TGD	TFC	65. Verify firing system SAFE.	65____		
	TGD	TD	66. Technical/Safety Reentry Party assemble at Test Control Building.	66____		
	ATC	RT	67. Inform NR that external roadblock may be lifted.	67____		
	TGD	RB1/RB2	68. Reestablish internal roadblock.	68____		
T+20	TGD	TD	69. Request turn OFF laser.	69____		
	TGD	LPO	70. Direct turn OFF of laser.	70____		
		LPO	71. Confirm turn OFF of laser.	71____		
	TGD	TD	72. Direct reentry party (equipped with laser goggles) to proceed to GZ.	72____		
	TGD	MC	73. Verify C-47 is clear of WSMR.	73____		
T+21		TD	74. Confirm arrival at GZ.	74____		
	TGD	LPO	75. Direct turn ON of laser.	75____		
T+60	TGD	LPO	76. Direct turn OFF of laser.	76____		
		LPO	77. Confirm turn OFF of laser.	77____		
	TGD	TD	78. Initiate reentry plan.	78____		

Pre-DICE THROW DRAWING REFERENCE LIST

DNA Drawings

White Sands Missile Range QUEEN FIFTEEN TEST AREA, Pre-DICE THROW II-1:

Drawing No.	Description
1	Site Plan
2	Trench Test
2.1	Trench Details
2.2	Trench Installation Plan
3	Debris Test

FARSONS Drawings

S-1	Test Articles Cylinder's Fabrication
S-2	Test Articles Cylinder's Fabrication
S-3	Test Articles Arch Fabrication
S-4	Test Articles Cylinder End Plate
S-5	Test Articles Arch End Plate
S-6	Test Articles Cylinder Instrumentation
S-7	Test Articles Instrumentation
S-8	Test Articles Arch Instrumentation
S-9	Test Articles Cylinder Installation Dets.
S-10	Test Articles Arch Installation Dets.
S-11	Test Articles Cylinders Shipping Dets.
S-12	Test Articles Arches Shipping Dets.
S-13	Test Articles Cylinder Recovery Det.
S-14	Test Articles Arch Recovery Det.
S-15	Facility Test Area Pre-Test Site Work
S-15a	Test Articles Cylinder Installation Dets.
S-16	Test Articles Arch Installation Dets.
S-17	Facility Test Area Pre-Test Site Work
S-18	Test Articles Cylinder Recovery Dets.
S-19	Test Articles Arch Recovery Dets.

DICE THROW DRAWING REFERENCE LIST

DNA Drawings

Drawing No.	Description
DT-1000	Site Plan
1001	Test Bed Layout
1001A	Test Bed Layout Post-Shot Structures
1002	Survey Control Points
1003	Grading Plan
1004	Power Distribution
1005	Cable Plan
1006	Trailer Parks
1007	Timing and Firing
1008	Misc. Details (Trailer Door Shock Absorber)
1020	ARMCOM Experiment Layout
1021	SRI Experiment Layout
1022	BRL/BEWV Experiment Layout
1023	BRL/CCC Experiment Layout
1024	BRL/HELO Experiment Layout
1025	BRL/GL Experiment Layout
1026	ORNL Experiment Layout
1027	NWEF Experiment Layout
1028	Lovelace Experiment Layout
1029	DRES Experiment Layout
1030	UK/ASWE Experiment Layout
1031	SAC Experiment Layout
1032	Sweden Experiment Layout
1033	Norway Experiment Layout
1034	AFWL Experiment Layout
1035	WES/FRG Experiment Layout
1036	DRI Experiment Layout
1037	SRI/FRG Experiment Layout
1038	SLA Experiment Layout

DICE THROW DRAWING REFERENCE LIST (Continued)

DNA Drawings (Continued)

Drawing No.	Description
DT-1039	Boeing Experiment Layout
1040	CERF/AFWL Experiment Layout
1041	CDD Experiment Layout

SRI Drawings

SRI-4629-1	Site Plan and General Notes
A1	Elevations and Details
A2	Plans and Sections
A3	Half-Timber Side Wall

NSWC Drawings

NSWC 76C-1127	Main Booster Assembly
76D-1128	Main Booster Assembly
76D-1123	Booster Initiation System
76D-1129	Booster Initiation System

FRG Drawings

1	Site Layout DICE THROW Event
2	Concrete Design Box Structures S1a, S1b, S2a, S2b, S3a, S3b and Burster Slab
3	Steel Placement S1a and S1b
4	Steel Placement S2a and S2b
5	Steel Placement S3a and S3b
6	Steel Schedule for FRG Structures
7	Structure Placement Concrete Structures S1a and S1b
8	Structure Placement Concrete Structures S2a, S2b, S3a, S3b
9	Structure Placement Precast Concrete Structures S4a and S4b
10	Excavation Plan Prefab Structures S5a and S5b
11	Pre-Fabricated Steel Structures S5a and S5b
12	Excavation Plan Prefab Structures S5a and S5b

DICE THROW DRAWING REFERENCE LIST (Continued)

FRG Drawings (Continued)

Drawing No.	Description
13	Structure Placement Steel Blast Doors D1a and D1b
14	Concrete and Steel Design Reaction Structure for Blast Doors D1a and D1b

AFWL Drawings

60-09-01	Site Layout Plan
	Aircraft Shelter Models
(1)	Door Sections, Details and Elevation
(2)	Shelter A Door Foundation (Plan, Roller Layouts, Reinforcing Schedule Sections and Details)
(3)	Shelter A, Door Foundation (Floor Plan, Sections, Elevations and Isometric)
(4)	Shelter A, B, C: Structural Details
(5)	Shelter B, C: Section Plan and Elevation
(6)	Shelter B, C: Reinforcement and Closure Sections
(7)	Shelter B, C: Structural Details and Sections
(8)	Shelter A and Door: Instrumentation Gage Location Details
(9)	Shelter B, C: Gage Placement Sections
(10)	Shelter A, B, C: Gage Placement Sections and Gage Mount Schedule
(11)	Shelter A, B, C: Gage Mount Details

DRES Drawings

MES-CDT-100-C2-1	Experiment Details
C3-1	Experiment Details
C4-1	Experiment Details
C4-2	Experiment Details
C4-3	Experiment Details
MES-CDT-104-1	Experiment Details
MES-CDT-105-1	Experiment Details

(Also refer to U.M.&A Drawing No. S-1)

PRE-DICE THROW AND DICE THROW REFERENCE DOCUMENTS LIST

Pre-DICE THROW Documents

Project	Agency	POP/ DNA No.
Preliminary Results Report	FC/DNA	6904
ANFO Charge Development	AFWL	6905
MX Trench Experiment	SAMSO	6906
MX Structure Experiment	SAMSO	6907
Stress Measurements	SRI	6908
Stress and Airblast Measurements	SSS	6909
Ground Motion and Stress Measurements	WES	6910
LIDAR Experiment	SRI	6911
Crater Measurements and Permanent Displacement	WES	6912
TNT Charge Construction and Diagnostics	DRES	6913
ANFO Airblast Calculations	AFWL	6914
Free-Field Airblast Measurements	BRL	6915
Technical Photography	DRI	6917
Particle Velocity Gage Development	AFWL	6918

PRE-DICE THROW II-1 DEBRIS AND TRENCH TESTS, Final Report
By: Karagozian and Case
For: SAMSO
Date: 6 November 1975

PRE-DICE THROW II-1 MX TRENCH SHEAR STRESS MEASUREMENTS, 26639-6003-RV-00
By: Richard G. Batt/TRW
For: SAMSO
Date: 15 January 1976

ANFO CHARGE DEVELOPMENT PROGRAM SUMMARY
By: Capt. Thomas Y. Edwards
Date: 21 June 1977

PRE-DICE THROW AND DICE THROW REFERENCE DOCUMENTS LIST (Continued)

DICE THROW Documents

Test Execution Report	FC/DNA	6965
Dynamic Response of Two Types of German House Construction	SRI	6966
Crater and Ejecta Enhancement Studies	AFWL/CERF	6967
Proceedings of the DICE THROW Symposium, 21-23 June 1977	DNA	DNA-4377P-1, 2 & 3

APPENDIX B

1. Countdown Procedures for DICE THROW

2. Radio Frequency Requirements on DICE THROW

3. DICE THROW and pre-DICE THROW 1, 2 Test Site Clean-Up/GIANT PATRIOT and QUEEN 15 Areas

4. FCDNA-Designed Debris Suppression and Crater and Seismic Predictions for DICE THROW

5. BRL Predicted Airblast Parameters

6. SLA Predictions of Free Airblast Isobars and Extended-Range Airblast Pressures for DICE THROW

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL ATC	INITIAL CTC	INITIAL TGD
T-13 Hrs	ATC	NR	1. Establish Road Blocks: (1) Rt 20 at Rt 7 eastbound. (2) Rt 7 entrance to Trailer Park #1. (3) Rt 20 at Trinity westbound.	1____			
		TGD	2. Verify area clear of all non-essential personnel	2____			
T-7 Hrs		TGD	3. Pickup countdown.	3____			
	TGD	PT	4. Confirm communications: (1) Project Net (2) Technical Net (3) T&F Discrete	4____			
		PO	5. Project Officers check-in with Test Control.	5____			
T-6 Hrs	TD	T&F	6. Commence signal dry runs as requested.	6____			
		TGD	7. Obtain latest weather forecast.	7____			
	TGD	ATC	8. Request permission to proceed with countdown.	8____			
		HELO	9. Conduct final pre-test helicopter test flight.	9____			
		TGD	10. Commence F-4 overflight.	10____			
T-5 Hrs/ 30 min		HELO	11. Report results of helicopter test flight.	11____			
T-5 Hrs/ 15 Min		TGD	12. Confirm F-4 clear of area.	12____			

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL ATC	INITIAL CTC	INITIAL TGD
T-5 Hrs	TGD	SACLO	13. Confirm SAC B-52's enroute.	13____			
		PT	14. Confirm communications: (1) Range Net (2) SAC Coordinator Net (3) WSMR Air Control Net (LISTEN ONLY) (4) Air Surveillance Net	14____			
T-4 Hrs/ 15 Min	TD	T&F	15. Final 5-minute Signal Dry Run to countdown.	15____			
T-4 Hrs	ATC	NR	16. Establish Traffic Control at Rt 7 entry to G-160 and Rt 20 westbound from Rt 7.	16____			
	TD	T&F	17. Complete Signal Dry Run	17____			
T-2 Hrs/ 30 Min		DTGD	18. VIP's assemble in Admin Area Conference Room (Strode/Klimmek).	18____			
T-2 Hrs/ 15 Min		TGD	19. Clear test bed personnel except for designated personnel.	19____			
T-2 Hrs		DTGD	20. Commence VIP tour of test bed (Observation Mound).	20____			
		PT	21. Experimenters report readiness for test & clearing of trailer parks and bunkers for designated positions.	21____			
		MET	22. Meteorologic release.	22____			

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL		
					ATC	CTC	TGD
T-1 Hr/ 30 Min	ATC	NR	23. Establish external roadblocks.	23____			
		DTGD	24. Complete VIP tour - return to Admin Area Conference Room.	24____			
		TD	25. Conduct final sweep of test bed.	25____			
		TD	26. Arming Party assemble at Trailer Park #2.	26____			
		TGD	27. Confirm 7th Special Forces in position and ready.	27____			
	ATC	NR	28. Conduct aerial sweep of test area.	28____			
T-1 Hr/ 15 Min		TGE	29. VIP's depart Admin Area for OP (LT Klimmek)	29____			
	TGD	PO	30. Experimenters clear trailer parks and bunkers.	30____			
	ATC	TGD/NR	31. Confirm radar avoidance and RF propagation shutdown.	31____			
		TGD	32. Receive results of T-2 Hrs meteorologic release.	32____			
T-1 Hr/ 10 Min	TGD	TD	33. Confirm Firing Circuit safe.	33____			
	ATC	NR	34. Confirm personnel clear to internal roadblocks.	34____			
	ATC	TGD	35. Request permission to pre-arm.	35____			
T-60 Min		TGE	36. Confirm VIP arrival at OP (LT Klimmek)	36____			
	TGD	TD	37. Commence pre-arming.	37____			
		PT	38. Countdown at 5-minute intervals until T-10 minutes.	38____			

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL		
					ATC	CTC	TGD
		NR	39. Confirm B-52's on station.	39____			
T-50 Min		MET	40. Meteorologic release.	40____			
	ATC	TGD	41. Request permission to arm.	41____			
T-45 Min		NR	42. Confirm photographic airplane on station.	42____			
	TGD	TD	43. Commence final arming.	43____			
T-30 Min		TD	44. Arming complete. Arming party depart for designated stations.	44____			
	TGD	DRI	45. DRI clear to make spectograph check.	45____			
	ATC	PT	46. Open Range Net.	46____			
		NR	47. Confirm C-135 aircraft on station.	47____			
T-20 Min		TD/OP	48. Confirm arrival of Arming Party at designated stations.	48____			
		DRI	49. Confirm DRI in bunker.	49____			
		TD/OP	50. Confirm all personnel at designated positions.	50____			
T-15 Min		TGD	51. Receive final meteorologic conditions report.	51____			
		TGD	52. Confirm readiness for test.	52____			
		TGD	53. Activate RF transmitters.	53____			
T-10 Min		PT	54. Countdown at 1-minute intervals until T-60 seconds.	54____			
	TGD	TD	55. Request permission to ready firing panel.	55____			

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL ATC	INITIAL CTC	INITIAL TGD
		HELO	56. Start helicopter.	56____			
T-5 Min to T-3 Min		TD	57. Confirm firing panel ready.	57____			
		ATC	58. Confirm Range GREEN.	58____			
		TD	59. Confirm status of power and temperature monitors.	59____			
T-3 Min		TGD	60. Confirm test is GO.	60____			
		TD/TGD	61. Confirm manned stations ready for test.	61____			
T-2 Min		HELO	62. Helicopter in position for test.	62____			
T-60 Sec		PT	63. Countdown at 5-second intervals until T-20 seconds.	63____			
T-45 Sec		TD	64. High Voltage confirmed.	64____			
T-20 Sec		PT	65. Countdown at 1-second intervals until T+5 seconds.	65____			
T-0		TD	66. Detonate charge.	66____			
		MET	67. Meteorologic release.	67____			
T+5 Sec		ATC	68. Confirm detonation with National Range.	68____			
		TD/TGD	69. Confirm status of personnel at manned stations (Trailer Parks and Bunkers, and 7th Special Forces)	69____			

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL ATC	INITIAL CTC	INITIAL TGD
T+1 Min		TGD	70. Safety Party enroute to Trailer Park #2.	70____			
		OP	71. Priority 1 Reentry Party enroute to Admin Area.	71____			
		HELO	72. Confirm Helicopter landing and shut down.	72____			
T+10 Min		TD/SF	73. Safety Party verify area clear of explosives - report location of any fires or hazards.	73____			
		TGD	74. Priority 1 Reentry Party clear to reenter.	74____			
		TGE	75. VIP's proceed from OP to Admin Area Conference Room.	75____			
T+15 Min	ATC	NR	76. Establish roadblocks at: (1) Rt 7 entry to Trailer Park #1. (2) Rt 20 at Rt 7 eastbound. (3) Rt 20 at Trinity westbound.	76____			
		TD	77. Priority II Reentry Party clear to reenter test bed.	77____			
T+20 Min	ATC	NR	78. Lift external roadblocks.	78____			
		PT	79. Secure Range Net.	79____			
	TGD	OP	80. Release personnel from OP.	80____			
		ATC	81. Mission Complete - Time _____ hours.	81____			
		TGD/DTGD	82. Conduct VIP tour to observation mound.	82____			
	TGD/ DTGD	PO	83. (Foreign National Guests released to agencies sponsoring foreign experiments.)	83____			

COUNTDOWN PROCEDURES FOR
DICE THROW

T-TIME (Min)	DIR OF	ACTION BY	OPERATION	CHECK	INITIAL		
					ATC	CTC	TGD
T+45 Min		TGD/DTGD	84. Complete VIP tour - return to Admin Area Conference Room.	84____			
T+2 Hr/ 30 Min	TGD	NR	85. Lift remaining roadblocks.	85____			

RADIO FREQUENCIES REQUIRED ON DICE THROW

Frequency (MHz)	Description
166.0	Main Net based in ADMIN AREA
38.85	Artillery Support
36.7	C^3—AN/VAC-12 equipment
255.5	
243.5	
303.5	
337.5	
377.5	
397.5	
1,364.5	C^3—AN/GRC-103 equipment
1,428.5	
1,433.5	
1,731.5	
1,766.5	
1,785.5	
1,811.5	
1,839.5	
378.609	SRI experiment
413.501	
424.501	
447.447	
1,239.084	
1,273.503	
2,891.196	
8,914.521	
10,188.024	
216.5	SLA Airblast (Reed) Telemetry
217.5	
218.5	
219.5	
230.5	
239.5	
248.5	
259.7	
413.8	SLA Air (Reed) Voice
268.0	ACFT SAC Primary
280.8	ACFT SAC Secondary

DICE THROW TEST SITE CLEANUP/GIANT PATRIOT

1. HELO EXPERIMENT
   - Remove bunkers from berms and load for shipment.
   - Level berms.
   - Remove 40-ft utility pole.

2. ARMCOM EXPERIMENT
   - Remove underground Command Post, Instrumentation bunker and substation bunker; backfill holes.
   - Drive rebar RP's flush with ground.

3. LOVELACE EXPERIMENT
   - Remove bunkers and backfill holes.

4. SRI RF EXPERIMENT
   - Dispose of main transmitter.
   - Return CONEX to WSMR logistics.
   - Remove T&F road crossing.

5. SWEDISH EXPERIMENT
   - Weld hatches closed and berm over hatches.

6. NORWEIGAN EXPERIMENT
   - Bolt steel plate over entrance and backfill.

7. DRES EXPERIMENT
   - Cut anchor bolts on all concrete pads.
   - Remove camera posts.
   - Level IT bunker.
   - Cover cable trench.
   - Load Instrumentation bunker for shipment.

8. UK EXPERIMENT
   - Cut anchor bolts on all concrete pads.
   - Remove camera posts; level berms.

9. CCC EXPERIMENT
   - Level sandbagged berm and backfill large trench.
   - Remove 12 utility poles.
   - Drive rebar RP's flush with the ground.

10. WV EXPERIMENT

- Drive rebar RP's flush with ground.
- Dispose of debris not removed by salvage.
- Move concrete blocks to storage area.

11. WALL EXPERIMENT (After 1 Nov 76)

- Dispose of all debris.
- Structurally sound walls may remain.

12. WES/FRG EXPERIMENT

- Dispose of debris from Blast Doors; level berms.
- Close entrances to S1a, S1b, S2a, S2b, S3a, and S3b; backfill entrance holes.
- Weld trap doors closed on S4a and S4b and backfill entrances.
- Backfill entrances to S5a and S5b.
- Remove VW-1.

13. APS EXPERIMENT

- Doze open, destroy and backfill all shelters.

14. AFWL EXPERIMENT

- Load blast door.

15. ORNL EXPERIMENT

- Doze in all shelters.

16. BRL FREEFIELD GAGES

- Remove all above-ground gage mounts.

17. DRI CAMERA MOUNTS

- Remove all steel camera mounts.

18. TRAILER PARKS

- Uncrib trailers and disconnect power lines.
- Remove debris after all trailers have been removed.

19. CABLE

- All cable lying in open trenches not recovered by FCDNA shall be bladed over.

20. ADMIN AREA

- Cut utilities.
- Remove outdoor storage area.
- Return guard building to Stallion Range Center.
- Disposition of FCDNA trailers is unknown at this time.

QUEEN 15 SITE CLEANUP

1. Dispose of debris in LASS area and around trailer park.
2. Dispose of LASS cable and cable in trailer park.
3. Backfill LASS craters, 5-ton crater and dump pit behind trailer park.
4. Remove concrete culverts.

DNA-DESIGNED DEBRIS SUPPRESSION AND CRATER AND SEISMIC PREDICTIONS FOR DICE THROW

Figure B-1. Proposed Debris Suppression, DICE THROW

Table B-1. DICE THROW Crater Predictions

Table B-2. DICE THROW Seismic Predictions

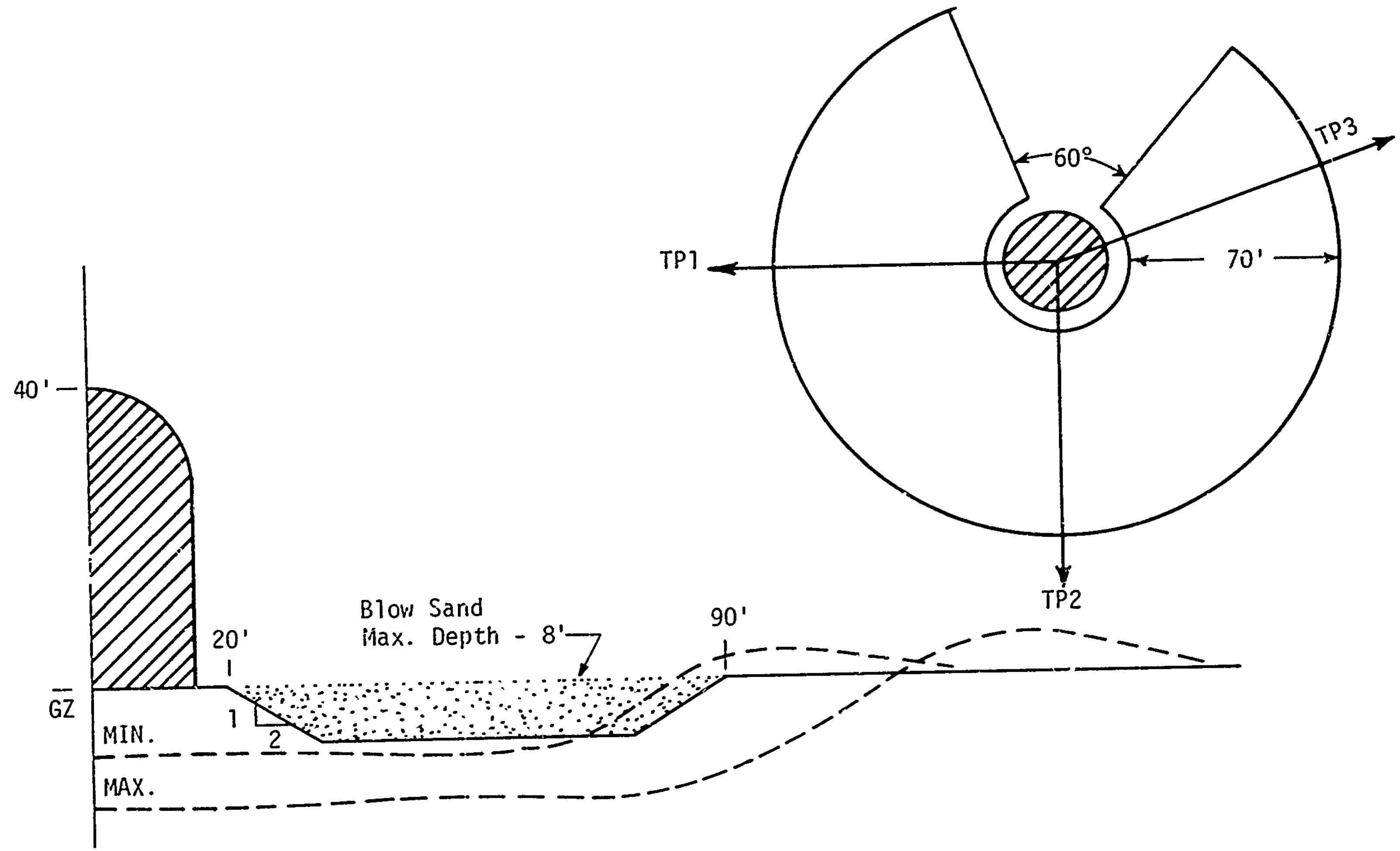


Figure B-1. Proposed Debris Suppression, DICE THROW

Table B-1. DICE THROW Crater Predictions
16 January 1976

LIP DIAMETER	200 - 250 FT
DEPTH FROM LIP	14 - 18 FT
LIP HEIGHT	5 - 8 FT
R_A	85 - 115 FT
D_A	10 - 15 FT
V_A	175K - 300K FT^3

Table B-2. Seismic Predictions

LOCATION	RANGE*(kft)	PEAK-TO-PEAK ACCELERATION, g's	PEAK-TO-PEAK DISPLACEMENT, in.
Trailer Parks 1, 2 & 3	6	0.06**	0.03**
Administration Park	10	0.02**	0.01**
Millers Watch	27	0.005	0.003
Stallion	63	0.001	0.001
Ben	63	0.001	0.001
San Antonio	135	<< 0.001	<< 0.001
Socorro	174	<< 0.001	<< 0.001
Truth or Consequences	309	<< 0.001	<< 0.001

*Ranges for WSMR Road Map

**Interpolation of MIXED COMPANY symposium[1] Tables 1 and 2, assuming that $D_v = D_r = D_t$ and $A_v = A_r = A_t$. All other data points are taken from MIXED COMPANY and MIDDLE GUST data extrapolations.

[1]Proceedings of the MIXED COMPANY/MIDDLE GUST Results Meeting, 13-15 March 1973, DNA 3151P2, Vol. II, pp 393 to 416, "Analysis of Strong Motion Surface Seismic Measurements," Lt. Robert L. Post, Jr., and Mr. Richard T. Zbur.

BRL PREDICTED AIRBLAST PARAMETERS AND GAGE LAYOUT FOR DICE THROW

Figure B-2.	Arrival Time versus Range
Figure B-3.	Overpressure versus Range
Figure B-4.	Overpressure Impulse versus Range
Figure B-5.	Positive Duration versus Range
Figure B-6.	Horizontal Dynamic Pressure versus Range
Figure B-7.	Horizontal Dynamic Pressure Impulse versus Range
Table B-3.	BRL Predicted Airblast Parameters

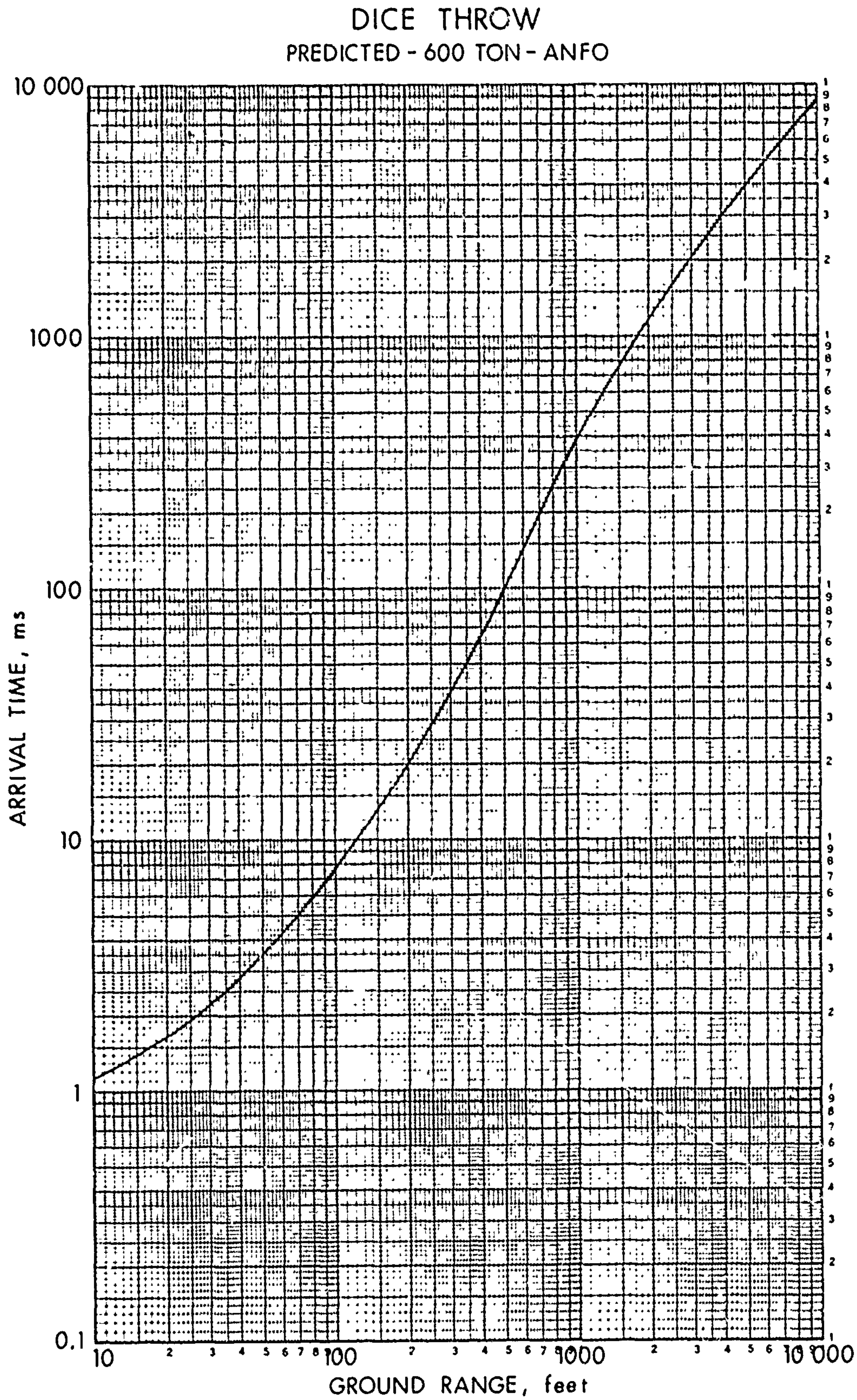


Figure B-2. Arrival Time versus Range

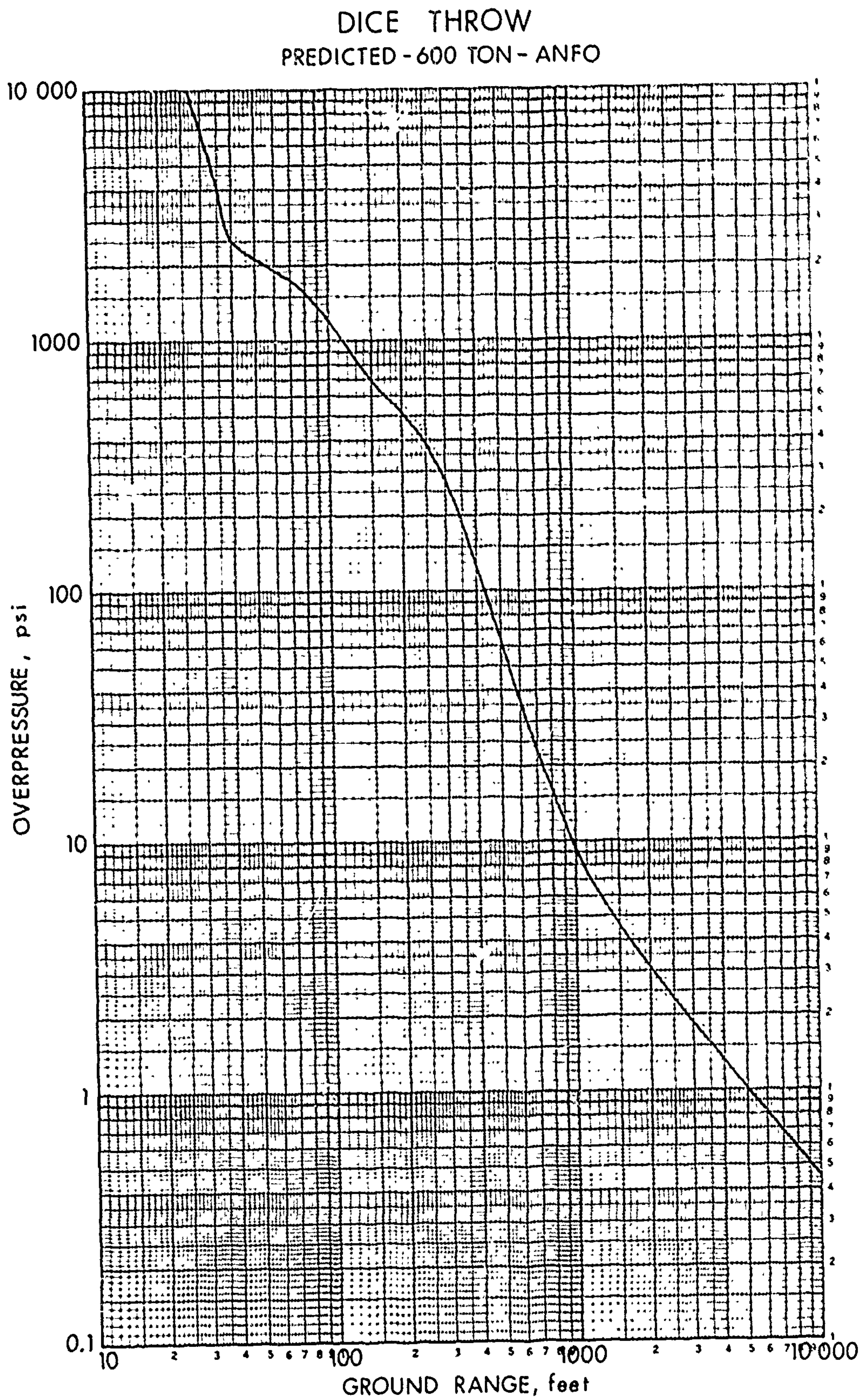


Figure B-3. Overpressure versus Range

DICE THROW

PREDICTED - 600 TON - ANFO

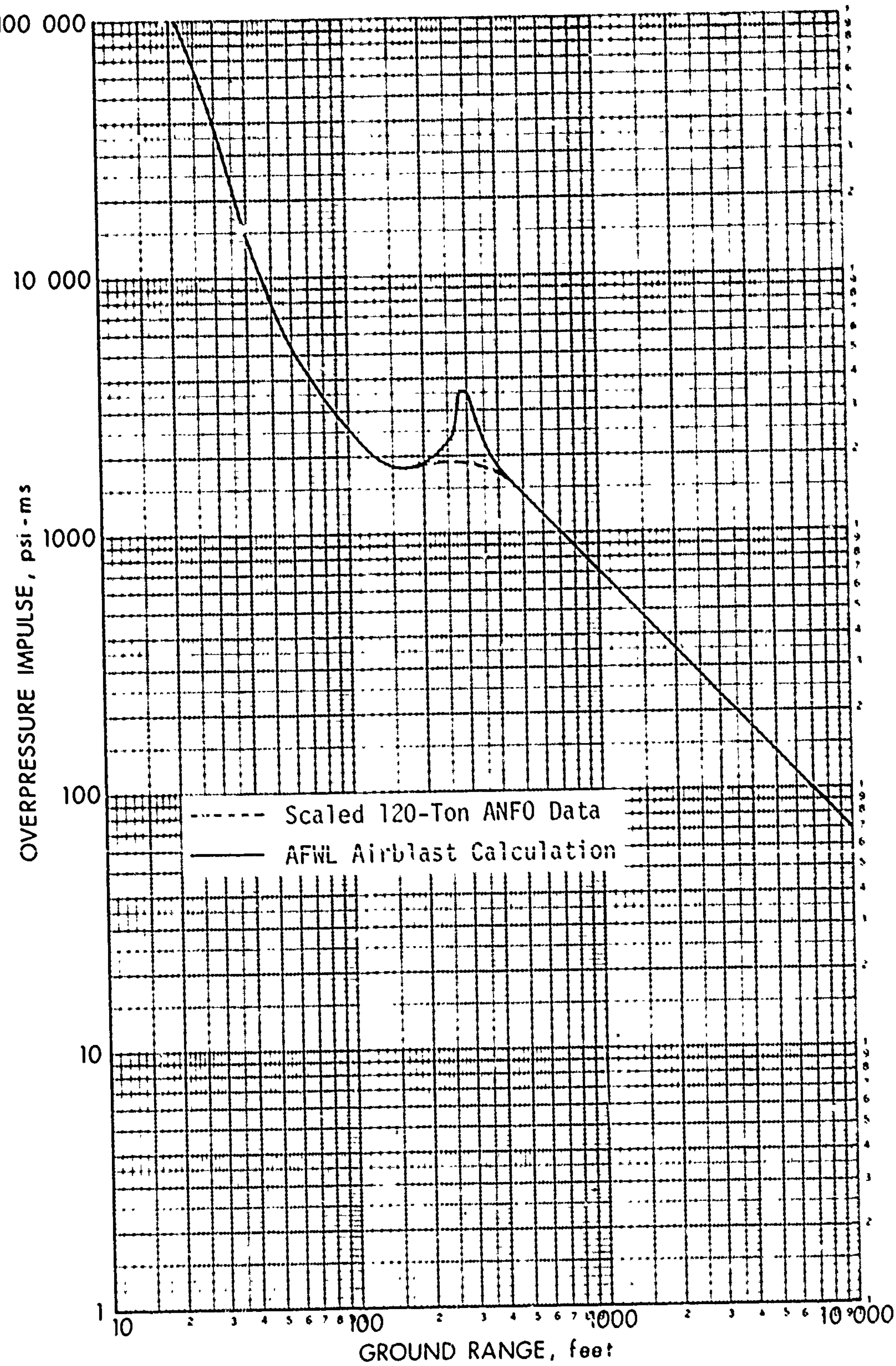


Figure B-4. Overpressure Impulse versus Range

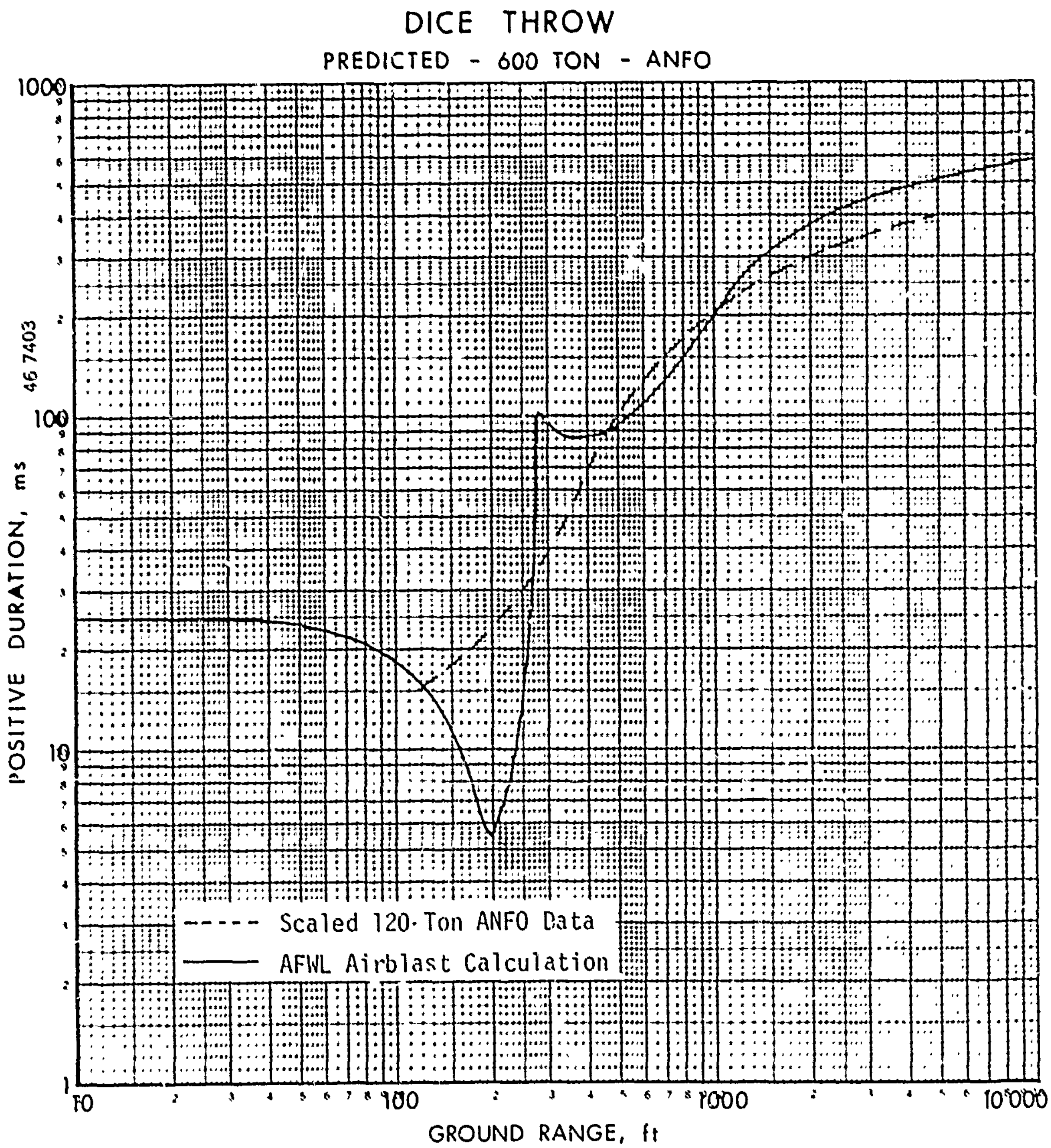


Figure B-5. Positive Duration versus Range

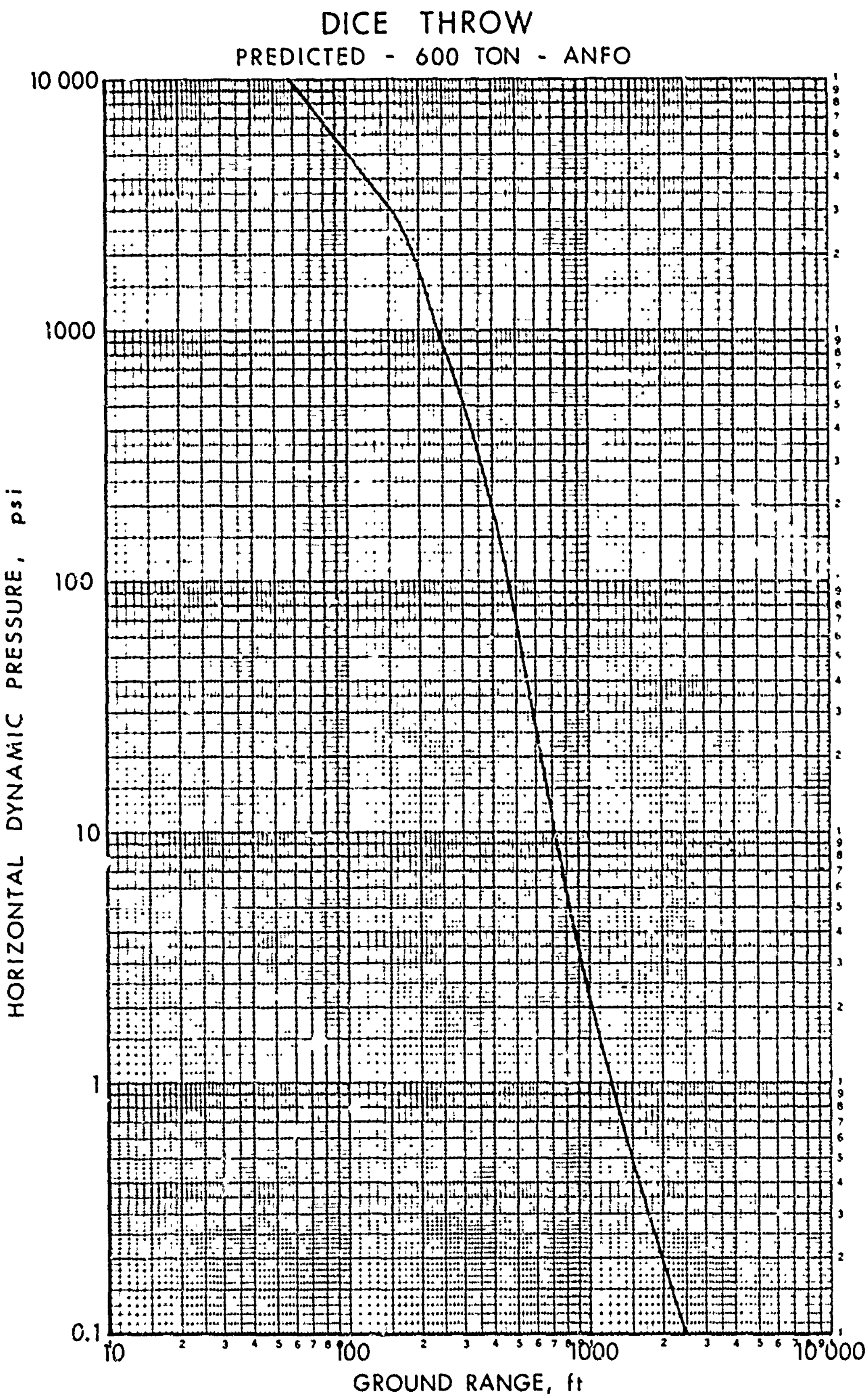


Figure B-6. Horizontal Dynamic Pressure versus Range

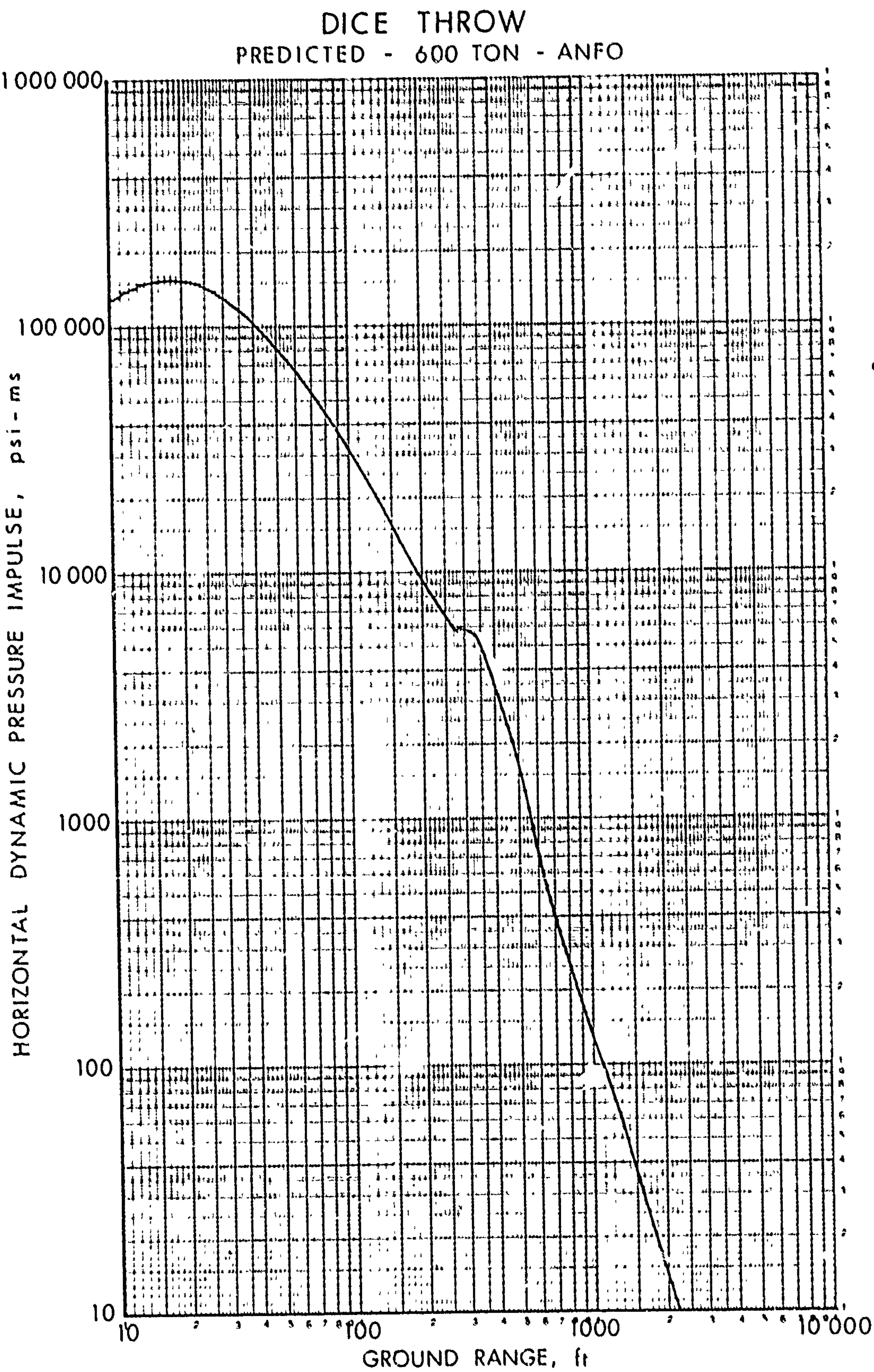


Figure 3-7. Horizontal Dynamic Pressure Impulse versus Range

Table B-3. Operation Middle North – Event DICE THROW
Predicted Air Blast Parameters

P_o = 12.58 psi T_o = 12°C

XCORD (ft)	OP (psi)	AT (ms)	PPD (ms)	OPI (psi-ms)	HDP (psi)	HDPI (psi-ms)
32.4	5000.	2.35	24.4	27500.	--	--
37.4	3000.	2.65	24.3	17000.	--	--
50.0	2100.	3.50	23.9	8000.	--	--
100.	1200.	7.60	18.2	2540.	5200.	31000.
113.	1000.	9.20	16.6	2160.	4300.	26000.
150.	700.	13.2	11.2 (17.5)	1800.	3150.	15000.
200.	510.	20.0	5.6 (22.4)	1830.	1750.	9400.
206.	500.	21.0	6.0 (23.0)	1870.	1600.	9000.
250.	380.	28.3	14.0 (30.0)	2220. (1900.)	890.	6600.
281.	300.	34.0	100. (38.5)	3600. (1900.)	640.	5800.
300.	270.	37.5	96.0 (43.0)	3650. (1870.)	530.	5800.
310.	250.	39.5	92.0 (46.0)	3500. (1850.)	490.	5750.
332.	210.	44.0	88.0 (51.0)	2650. (1840.)	385.	5500.
350.	185.	48.5	86.0 (56.0)	2140. (1820.)	320.	5100.
400.	127.	61.0	86.0 (70.0)	1750.	193.	3500.
440.	100.	73.0	88.0	1620.	130.	2650.
450.	90.0	76.0	89.0	1550.	120.	2400.
500.	65.0	94.0	92.0	1400.	73.0	1650.
515.	60.0	100.	95.0	1330.	64.0	1450.
525.	55.0	104.	97.0	1320.	56.0	1325.
550.	48.0	115.	100.	1240.	45.0	1100.
570.	45.0	123.	103.	1200.	37.0	900.
580.	40.0	128.	105.	1160.	33.0	790.
600.	36.0	137.	109.	1130.	28.0	700.
605.	35.0	140.	110.	1120.	26.0	670.
640.	30.0	156.	114.	1050.	19.0	570.
650.	28.0	164.	117.	1030.	17.0	530.
680.	25.0	183.	122.	990.	13.4	450.
700.	23.0	196.	126.	960.	11.2	390.
740.	20.0	220.	134.	910.	8.8	330.

Table B-3. Operation Middle North — Event DICE THROW

Predicted Air Blast Parameters - Continued

XCORD (ft)	OP (psi)	AT (ms)	PPD (ms)	OPI (psi-ms)	HDP (psi)	HDPI (psi-ms)
750.	19.5	224.	138.	900.	8.3	315.
800.	16.3	255.	150.	840.	6.0	250.
820.	15.0	265.	152.	820.	5.2	235.
850.	14.0	290.	160.	790.	4.5	205.
900.	12.2	320.	172.	750.	3.5	170.
950.	10.7	350.	185.	710.	2.8	145.
965.	10.0	365.	189.	695.	2.5	135.
1000.	9.6	380.	200.	675.	2.2	125.
1050.	8.4	440.	217.	640.	1.70	103.
1075.	8.0	450.	223.	630.	1.60	99.0
1100.	7.8	460.	230.	620.	1.50	95.0
1112.	7.5	465.	232.	615.	1.43	92.0
1120.	7.3	470.	235.	610.	1.38	88.0
1140.	7.0	490.	242.	600.	1.28	80.0
1200.	6.5	520.	256.	570.	1.10	75.0
1230.	6.0	550.	264.	550.	.98	66.0
1300.	5.7	600.	278.	525.	.84	59.0
1370.	5.0	660.	291.	495.	.68	48.0
1400.	4.8	675.	296.	490.	.63	45.0
1500.	4.6	750.	310.	460.	.50	36.5
1575.	4.0	810.	320.	435.	.42	30.5
1600.	3.9	830.	325.	430.	.40	29.0
1700.	3.8	910.	340.	405.	.33	24.0
1730.	3.50	945.	345.	400.	.30	22.5
1800.	3.35	1000.	350.	385.	.27	20.0
1900.	3.20	1080.	365.	365.	.22	16.5
2000.	2.95	1150.	375.	350.	.19	14.2
2200.	2.60	1325.	395.	320.	.14	10.1
2400.	2.43	1500.	410.	290.	.10	--
2600.	2.12	1680.	425.	270.	--	--
2750.	2.00	1820.	430.	255.	--	--
2800.	1.94	1850.	435.	250.	--	--
3000.	1.80	2025.	445.	235.	--	--
3500.	1.48	2450.	470.	200.	--	--
4000.	1.25	2900.	480.	175.	--	--

Table B-3. Operation Middle North — Event DICE THROW
Predicted Air Blast Parameters - (cont'd)

XCORD (ft)	OP (psi)	AT (ms)	PPD (ms)	OPI (psi-ms)	HDP (psi)	HDPI (psi-ms)
4500.	1.10	3400.	--	--	--	--
5000.	.97	3800.	--	--	--	--
5500.	.87	4300.	--	--	--	--
6000.	.79	4700.	--	--	--	--
6500.	.71	5200.	--	--	--	--
7000.	.65	5600.	--	--	--	--

Note: Values in ( ) are from Pre-DICE THROW II-2 scaled data where there is significant variation from HULL Code calculation.

XCORD = Ground Range
OP = Peak Shock Overpressure
AT = Shock Front Arrival Time
PPD = Positive-Phase Duration
OPI = Overpressure Impulse
HDP = Horizontal Dynamic Overpressure
HDPI = Horizontal Dynamic Overpressure Impulse

$S_p = 1.1685$

$S_d = 0.0089$

$S_t = 0.0089$

$S_I = 0.0104$

SLA PREDICTIONS OF FREE AIRBLAST ISOBARS AND EXTENDED-RANGE AIRBLAST PRESSURES FOR DICE THROW

Figure B-8. Free Airblast Isobars

Figure B-9. Airblast Pressures at Extended Ranges

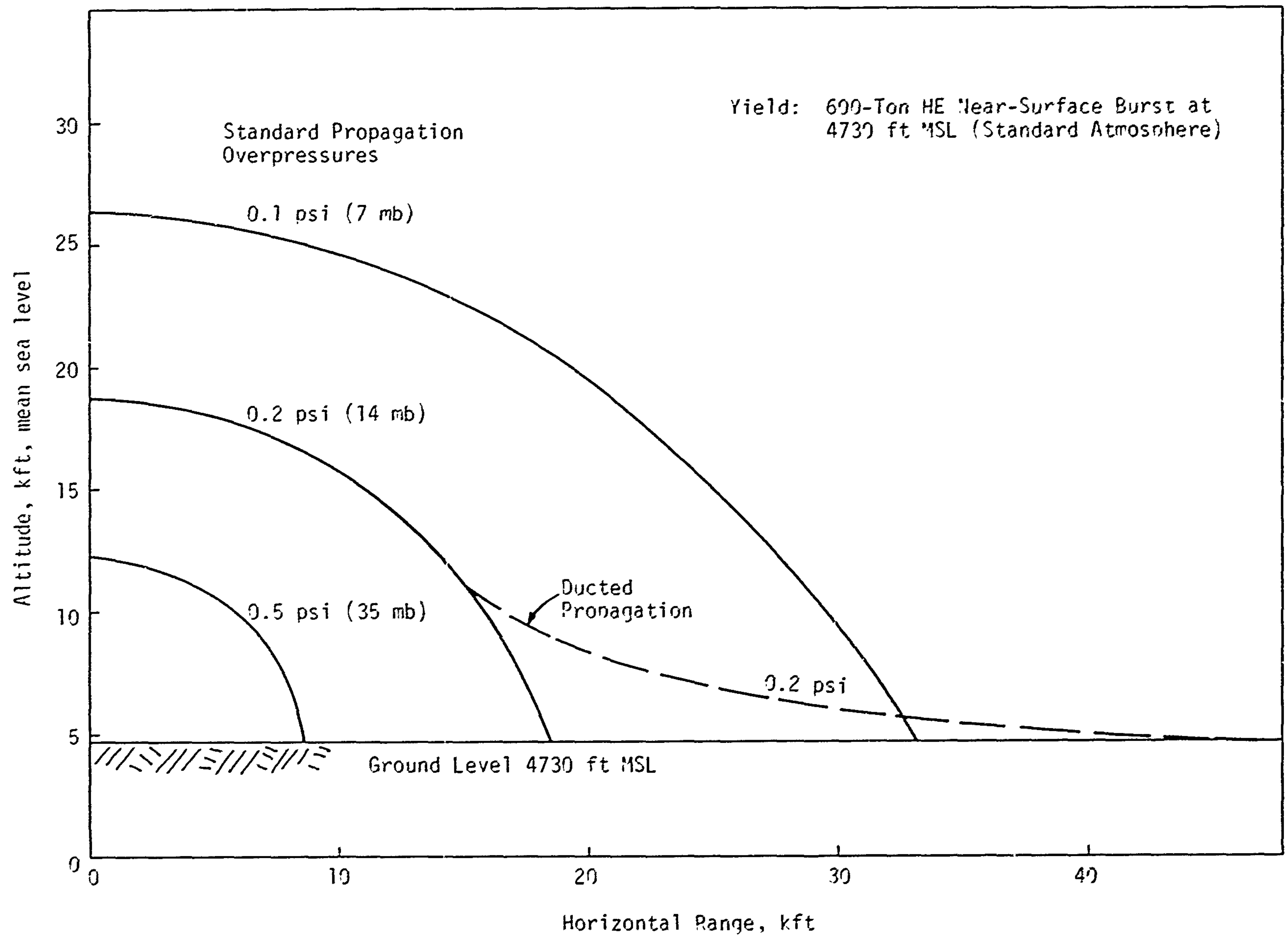


Figure B-8. DICE THROW Free Airblast Isobars, SLA Prediction

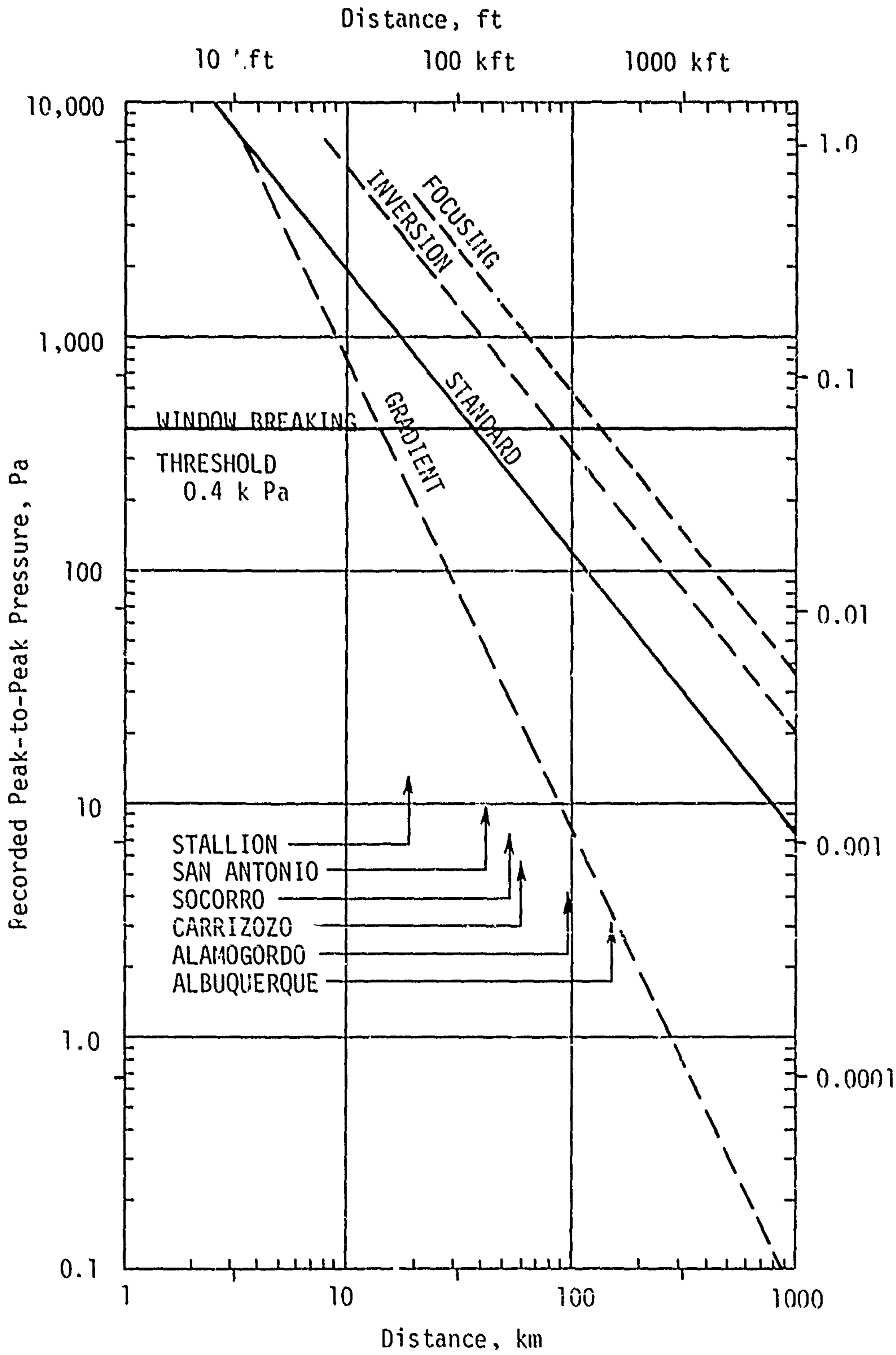


Figure B-9. Airblast Pressures from DICE THROW SLA Prediction

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ATTN: Code 715

Officer-in-Charge
Civil Engineering Laboratory
Naval Construction Battalion Center
ATTN: S. Takahashi
ATTN: Technical Library
ATTN: R. Odello

Commander
Naval Electronic Systems Command
Naval Electronic Systems Cmd. Hqs.
ATTN: PME, 117-21A

Commander
Naval Electronics Systems Command
Southwest Division
ATTN: Code 5034

Commander
Naval Facilities Engineering Command
Headquarters
ATTN: Code 09M22C
ATTN: Code 04B
ATTN: Code 03A

Superintendent (Code 1424)
Naval Postgraduate School
ATTN: Code 2124, Tech. Rpts. Librarian

Director
Naval Research Laboratory
ATTN: Code 8440, F. Rosenthal

Officer-in-Charge
Naval Surface Weapons Center
ATTN: Code WA501, Navy Nuc. Prgms. Off.
ATTN: M. Swisdake

Commander
Naval Weapons Center
ATTN: Code 3263
ATTN: Code 533, Tech. Lib.
ATTN: C. Austin

Commanding Officer
Naval Weapons Evaluation Facility
ATTN: Technical Library

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Strategic Systems Project Office
ATTN: NSP-43

DEPARTMENT OF THE AIR FORCE

AF Institute of Technology, AU
ATTN: Library, AFIT, Bldg. 640, Area B

AF Weapons Laboratory, AFSC
ATTN: SUL
ATTN: DEV
ATTN: DES-S
ATTN: DES-C, R. Henny
ATTN: DED, J. Renick
ATTN: DYT, C. Needham

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Commander
Foreign Technology Division, AFSC
ATTN: NICD, Library

Hq. USAF/RD
ATTN: RDQS

SAMSO/MN
ATTN: Capt. J. Kaiser
ATTN: MNNH, Maj. Gage
ATTN: Capt. T. Edwards

Commander in Chief
Strategic Air Command
ATTN: XPFS, Maj. B. Stephan

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Division of Military Application
ATTN: Doc. Con. for Test Office

University of California
Lawrence Livermore Laboratory
ATTN: Doc. Con. for M. Finger
ATTN: Doc. Con. for B. Hayes
ATTN: Doc. Con. for Tech. Info. Dept. Lib.

Oak Ridge National Laboratory
Union Carbide Corporation-Nuclear Division
X-10, Laboratory Records Department
ATTN: Doc. Con. for Tech. Lib.
ATTN: Doc. Con. for Civ. Def. Res Proj., Mr. Kearny

Sandia Laboratories
ATTN: Doc. Con. for L. Vortman
ATTN: Doc. Con. for Tech. Library Dept.

Sandia Laboratories
Livermore Laboratory
ATTN: Doc. Con. for Library & Sec. Class Div.

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Colorado Seminary
Denver Research Institute
ATTN: Sec. Officer for J. Wisotski

Electromechanical Sys. of New Mexico, Inc.
ATTN: R. Shunk

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Center for Advanced Studies
ATTN: W. Chan
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Kaman Sciences Corporation
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Lovelace Foundation for
Medical Education & Research
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ATTN: C. Mo
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ATTN: H. Cooper
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Science Applications, Inc.
ATTN: Technical Library

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ATTN: W. Baker

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ATTN: G. Abrahamson

Systems, Science & Software, Inc.
ATTN: Technical Library
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The Eric H. Wang Civil Engrg. Rsch. Fac.
University Station
ATTN: G. Lane
ATTN: G. Jones
ATTN: Tech. Library

Weidlinger Assoc., Consulting Engineers
ATTN: J. Isenberg

Weidlinger Assoc., Consulting Engineers
ATTN: M. Baron